UNIVERSITY OF BRISTOL

THE ANNUAL REPORT

OF THE

Agricultural and Horticultural Research Station

(THE NATIONAL FRUIT AND CIDER INSTITUTE)

LONG ASHTON, BRISTOL

1956

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Plant Physiology :
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E. J. SKERRETT, Ph.D., A.R.I.C.
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Administrative and Clerical Staff :—contd.

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Mrs. B. J. Taylor (née Haysham). (*Resigned* 31 *December*, 1956).
Miss N. K. Bullock.
T. J. Ford.
Miss J. M. Walters.
Mrs. M. Wippell.
Mrs. D. M. Sherborne (née Smith).
Miss M. J. Hathway.

Outdoor and Cider House Staff with more than 20 years' service :

R. Jones (34).
J. C. W. Barnes (28).
W. M. Hynam (28).
F. W. Hynam (27).
K. J. Escott (26).

Agricultural Research Council Unit of Plant Nutrition (Micro-Nutrients).

Honorary Director :
Professor T. Wallace, C.B.E., M.C., D.Sc., F.R.I.C., V.M.H., F.R.S.

H. E. Davenport, B.Sc., Ph.D. (*Appointed* 1 *May*, 1956).
E. J. Hewitt, B.Sc., Ph.D., A.K.C. (Seconded to Unit).
D. J. D. Nicholas, B.Sc., Ph.D., A.K.C., F.R.I.C.
R. A. Webb, B.A., D.Phil.
A. H. Williams, M.A., B.Sc.
H. M. Stevens, B.Sc., Ph.D.
A. J. Abbott, M.Sc., Dip. Hort.
O. T. G. Jones, B.Sc. (*Appointed* 26 *November*, 1956).
W. J. Redmond.
D. J. Fisher.
B. A. Notton, A.R.I.C. (*Returned from National Service* 15 *October*, 1956).
D. G. Hallas.
C. S. Gundry, S.D.H. (Greenhouse Experiments Officer). (*Up to* 31 *May*, 1956).
Miss E. Atkinson, B.Sc. (*Resigned* 25 *August*, 1956).
J. Jarrett.
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J. H. Scawin, A.R.I.C. (*Resigned* 5 *October*, 1956).
D. P. Hucklesby, B.Sc.
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J. S. Challice. (*On National Service from* 6 *December*, 1956).
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G. J. Dickes.
M. L. Passey. (*Appointed* 15 *October*, 1956).
J. K. Faulkner. (*Appointed* 1 *December*, 1956).
M. W. J. Heyes.
D. M. James.

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INTRODUCTION.

By T. WALLACE, Director.

The year 1956 has again been marked by steady progress of the research and other activities of the Institute.

A notable change in administrative responsibility for government grants to the Station was made from 1st April, 1956, when responsibility was transferred from the Ministry of Agriculture to the Agricultural Research Council. In the past the Ministry had been responsible for the administration of capital grants and the main annual block grant to the Station, whilst the Council had provided directly only special grants, such as that made for the work of the Unit of Plant Nutrition and for *ad hoc* projects. From 1st April, 1956, all grants from government sources will be made to the Station direct by the Council. In reporting this change we should like to place on record our indebtedness and thanks to the Ministry of Agriculture and its officers for their co-operation and unfailing help with our financial and administrative problems over many years.

Active collaboration has been continued with the N.A.A.S., both locally with the Provincial Officers and nationally through committees of the Ministry of Agriculture. The annual refresher course for N.A.A.S. Horticultural Officers and officers of County Council staffs was held at the Research Station on 3rd and 4th July and was attended by fifty-two officers. The Director has continued to serve on various committees concerning the work of the N.A.A.S., including the Agricultural Improvement Council and its Horticultural Experimental Committee, of which he is Chairman, the Fruit Working Party of that Committee, the Advisory Committees of the Experimental Horticulture Stations at Luddington, Efford, Rosemaund and Rosewarne, and as Chairman of the N.A.A.S. Fruit Group which is responsible for the Ministry of Agriculture bulletins and leaflets on fruit culture. The Station has also continued its collaboration in a number of field experiments at the Experimental Horticulture Stations.

The Colonial Office group of workers has continued its investigations under the special scheme referred to in previous Reports, and in this connection Dr. Kearns visited Zanzibar and East Africa over the period January 29th-March 7th, 1956, to review the progress of experiments on *Theraptus* beetle attacking coconuts in Zanzibar, and on the spraying of coffee in Tanganyika ; he also visited Uganda at the request of the Senior Government Entomologist.

Dr. R. A. Webb also continued his field experiments in the Gambia, and visited the territory for one month in November to assess the effects of fertilizer treatments as shown at the harvest period.

Other visits abroad of special interest were made by Mr. Marsh to Yugoslavia for three months beginning in April, and Dr. Luckwill for one month in May to Poland. The visit of Mr. Marsh was undertaken on behalf of F.A.O. to examine the existing research and advisory services in entomology and plant pathology in Yugoslavia, and to advise the Yugoslav government on the planning, organising and implementing of an improved pest and disease control service.

Dr. Luckwill's visit was in response to an invitation of the Research Institute of Pomology at Skierniewice to attend an International Scientific Pomological Conference arranged to celebrate the official opening of the Institute. The conference was followed by a tour of some of the fruit growing areas of Poland, which afforded an opportunity to assess the present state of the fruit industry and the general agricultural conditions in the country.

The main business of the Cider Advisory Committee during the year was in connexion with a proposal to reconsider the list of recommended varieties for planting agreed in 1947. The special sub-committee formed to consider this problem, under the chairmanship of Mr. J. B. Duggan, met on May 3rd to agree on its final recommendations, and these were discussed and agreed by the full committee at a meeting on 23rd October.

The new recommendations are published in this Report (p. 44) and will also appear in *Agriculture* early in 1957. The main difference between the old and new lists is the deletion of some varieties previously recommended for general planting and which, in the light of further experience, cannot be so recommended.

During the year agreement has been reached with the Ministry of Agriculture, through Mr. C. E. Hudson, the Chief Education Officer for Horticulture, for the close collaboration of N.A.A.S. horticultural officers in the cider counties in the work of the Institute's Trial Orchards Scheme. Thanks are due to the Ministry for agreeing to this co-operation, which should add greatly to the efficiency of the conduct of the trials, particularly in respect of management practices and crop recording.

The Cider Manufacture Sub-committee did not meet during the year, but its members individually approved the research programme of the Cider Section.

In April the Bath and West and Southern Counties Society published a pamphlet, written by Dr. Pollard, entitled "Cider Fruit Production." This pamphlet provides factual information relating to the present acreage and productive capacity of farm cider orchards and to commercial cider production in factories and on farms, and discusses problems of cider apple production in relation to the present and future needs of the cider making industry. The pamphlet should prove of special interest to farmers concerned with cider orcharding.

Some members of the A.R.C. Cider and Fruit Juices Committee visited the Station on April 5th to discuss research matters with the staff of the Cider Section. Unfortunately, on this occasion the chairman of the committee, Sir John Simonsen, was unable to be present and he was also prevented from paying us his usual annual visit in the autumn, because of illness. We regret that Sir John has felt unable to continue his chairmanship of the committee after 1956. Our thanks are due to him for the great interest he has shown in the work of the Cider and Fruit Juices Section and for the advice and help he has given on a number of problems.

As a result of progress made in the investigations on meat and poultry preservation, it has been possible to prepare a script for an Advisory Bulletin on the Domestic Preservation of Meat and Poultry. The bulletin will be published by the Ministry of Agriculture, Fisheries and Food.

During the year the Institute received the offer from Miss Constance Radcliffe Cooke of Much Marcle, Herefordshire, daughter of the late Mr. C. W. Radcliffe Cooke, M.P., J.P., one of the founders of the National Fruit and

Cider Institute, of a portrait of her father in coloured crayon, framed in gilt. The portrait was gratefully accepted by the Governors and Members of the Institute at the Annual Meeting of Members on 26th July, 1956, and has been hung in the Committee Room. We are greatly indebted to Miss Radcliffe Cooke for this generous gift. It was unfortunate that she was unable to undertake the journey to Long Ashton to make the presentation in person, as her presence at the ceremony would have given much pleasure to Members.

In the last Annual Report reference was made to the extension of courses in biology at the Bristol College of Technology, leading to the award of National Certificates similar to those awarded in chemistry. The College has now arranged for these at the National and Higher National levels in association with the Institute of Biology. The College is also providing sandwich courses of two and possibly four years' duration, in accordance with the recommendations of the Government White Paper on Training in Technology, and to meet the needs of students desiring to qualify in chemistry under the new regulations of the Royal Institute of Chemistry.

Whilst our assistant staff are making full use of the new courses in biology, they cannot at present enter for the sandwich courses without making considerable financial sacrifices. The new standards of the Royal Institute of Chemistry render it improbable that any of our assistant staff will in future be able to qualify for the Associateship of the Institute, as hitherto, whilst continuing in their posts at the Station.

We regret to record the deaths during the year of two valued friends of the Institute : Lady Bledisloe, wife of Lord Bledisloe, Chairman of the Agricultural Committee from 1920 to 1925, and Mr. G. H. Purvis, M.B.E., Principal of the Monmouthshire Institute of Agriculture, Usk, and an honorary member of this Institute since June 1939.

Lady Bledisloe had visited the Institute on several occasions with Lord Bledisloe and had taken a great interest in its work, particularly in that of the Domestic Preservation Section bearing on the activities of the Women's Institutes.

Mr. Purvis had been actively connected with the work of the Institute for many years and was the last of the group of pre-war County Agricultural Organisers who had been made honorary members of the Institute in recognition of their work on behalf of the Institute in their respective counties.

We are happy to record the award of the C.B.E. to Mr. C. E. Hudson in the New Year's Honours List and of the O.B.E. to Mr. R. A. Hughes in the Birthday Honours List. Both are officers of the Ministry of Agriculture, Fisheries and Food who have been closely concerned with the Institute during recent years, Mr. Hudson as a co-opted member of the Agricultural Committee and of its Finance and Business Sub-Committee, and Mr. Hughes as the Ministry Officer dealing with the Station's annual grants and capital developments.

Our congratulations are also due to Mr. E. W. Hobbis, who was appointed an Associate of Honour of the Royal Horticultural Society in November, and to Messrs. C. S. Gundry and D. G. Hallas, who were successful in winning the first and second prizes respectively in the first Station Essay Competition organized under the auspices of the Worshipful Company of Fruiterers.

Following the transfer of financial responsibility for the Station from the Ministry of Agriculture to the Agricultural Research Council, arrangements

were made for two representatives of the Council to serve on the University Agricultural Committee and for the Ministry to retain its one representative. The two members nominated by the Council are Professor E. J. Maskell, F.R.S., Professor of Botany, Birmingham University, and Mr. G. G. Samuel, an officer on the Council's scientific staff. Both of these newcomers are well known at the Station and we look forward to their joining us.

Mr. H. E. Keeler resigned from the Finance and Business Sub-Committee in February. He had been associated with the work of the committee since 1912, for many years in his capacity of University Auditor and recently, since his retirement from business, as a member of the committee. Our best thanks are due to Mr. Keeler for his wise guidance in financial matters over the years. We wish him a very long and happy retirement.

During the year two appointments of note were made to the Governing Body of the National Fruit and Cider Institute : Mr. G. J. Medley as the first representative of the Somerset County Branch of the National Farmers' Union, and Mr. J. H. Walker to succeed the late Mr. G. A. Nott in representing Worcestershire County Council.

We welcome this new association with the local branch of the N.F.U., whilst the appointment of Mr. Walker should strengthen still further our long and happy connexions with the agricultural education authority in Worcestershire.

Staff.

The Director was absent from the Station on sick leave from June 6th to September 5th, during which period Dr. H. G. H. Kearns and Mr. A. L. Leggett shared the administrative responsibilities.

The following staff changes occurred during the year :—

Appointments to Scientific Staff.

Mr. H. R. Mapother was appointed from 13th February, 1956, to the Entomology Section, to complete the team working under Dr. Kearns under the Colonial Office Scheme. Mr. Mapother is a graduate of Trinity College, Dublin, where he first graduated Honours B.A. in Experimental Science and subsequently B.Sc. with Honours in 1937. After leaving college he was employed on meteorological work in Jamaica for one year, after which he spent the period 1939–48 as an experimental officer in the Ministry of Supply analytical laboratory of the Projectile Development Establishment at Cardigan and the Chemical Inspectorate at the Royal Arsenal, Woolwich. In 1948 he transferred to the Fungicide and Insecticides Research Co-ordination Service of the Agricultural Research Council, and from 1949 to 1955 he was seconded to the Colonial Service as insecticide chemist at the West African Cacao Research Institute, Gold Coast. Mr. Mapother's past experience in the use of insecticides in the tropics makes him particularly well suited for his post at Long Ashton.

Dr. H. E. Davenport was transferred from the A.R.C. Unit of Plant Biochemistry, Cambridge University, to the A.R.C. Unit of Plant Nutrition at the Station from 1st May, 1956. He graduated B.Sc. (Honours), London, from University College, Nottingham, in 1939, subsequent to which he carried out postgraduate research, first on behalf of the Department of Scientific

and Industrial Research and then as a Ministry of Agriculture Scholar in the Department of Biochemistry at Cambridge. He was awarded the degree of Ph.D. (Cantab.) in 1945, after which he joined the A.R.C. Unit under Dr. R. Hill, F.R.S., and engaged in research on the identification and characterization of haematin pigments occurring in higher plants, which work he is continuing at Long Ashton.

Mr. O. T. G. Jones was appointed to the A.R.C. Unit of Plant Nutrition as biochemist in the section concerned with the nutrition of micro-organisms from 26th November, 1956. He graduated B.Sc. (Honours) in Biochemistry, University of Liverpool, in 1954, after which he carried out postgraduate research in biochemistry at Liverpool whilst holding a Medical Research Council Scholarship.

Appointments to Assistant Staff.

Miss S. M. Beresford : Following the retirement of Mr. G. T. Spinks as Librarian (part-time), Miss Beresford was appointed as the first full-time Librarian from 1st October, 1956. She graduated B.Sc. (Honours), Bristol, in General Science in 1950, and is also an Associate of the Library Association. Before joining Long Ashton she had been employed in the library of the Structural Research Laboratory of the Bristol Aeroplane Company and as assistant librarian at the Institute of Education, Bristol University.

Mr. C. S. Gundry was transferred from his post as Greenhouse Experiments Officer, A.R.C. Unit of Plant Nutrition, to that of Station Greenhouse Officer, and graded as Experimental Officer, from 1st June, 1956. This new appointment has been necessitated by the opening of the new greenhouse block referred to in the section on buildings.

Mr. J. S. Coles, Assistant Experimental Officer, was appointed as a plantations recorder on 16th January, 1956, to succeed Mr. D. W. Burd. During his period of training Mr. Coles worked on the plantations staff from 1947 to 1950. Among other qualifications he holds the Royal Horticultural Society's Diploma, N.D.H. (Fruit), and has had previous experience on the staffs of the Essex Institute of Agriculture and the National Fruit Trials, Wisley.

Mr. A. H. Sparks, Assistant Experimental Officer, was appointed as chemist to the Cider Section from 4th June, 1956, to succeed Mr. B. L. Davies, A.E.O., who was transferred to Organic Chemistry from 1st June, 1956. His previous experience has been as technician in the Departments of Physical and Biological Chemistry, University of Bristol.

Miss A. Tapscott, Assistant Experimental Officer, was appointed as chemist under the Colonial Office Scheme from 1st November, 1956. Miss Tapscott had previously been employed in the laboratories of the Imperial Tobacco Company.

Mrs. J. C. B. Waddington, Assistant Experimental Officer, was appointed as microbiologist in the Cider Section from 1st August, 1956, to succeed Mrs. Harrisson. She graduated in General Science B.Sc. (Honours) in the University of Bristol in 1956.

Mr. M. L. Passey, Assistant Experimental Officer, was appointed as chemist in the A.R.C. Unit of Plant Nutrition, Nutrition of Micro-organisms Section, from 15th October, 1956, to succeed Mr. J. H. Scawin. His previous experience has been in the Bristol City Analyst's Department. He served his period of National Service in the R.A.S.C.

Mr. J. K. Faulkner, Assistant Experimental Officer, was appointed as chemist in the A.R.C. Unit of Plant Nutrition, Nutrition of Micro-organisms Section, from 1st December, 1956, to succeed Miss E. Atkinson. He was previously employed in the Bristol City Analyst's Department.

Mr. L. G. Fish, Assistant (Scientific), Laboratory Assistant, from 1st April, 1956.

Miss P. J. Herrington, Assistant (Scientific), Entomology, from 22nd October, 1956, to succeed Mrs. Salway.

Miss A. Turner, Assistant (Scientific), Cider Microbiology, from 22nd October, 1956, to succeed Miss P. M. Hammond.

Retirement.

Mr. G. T. Spinks, Librarian (part-time), from 30th September, 1956.

Resignations : Assistant Staff.

Mr. J. F. Harris, Assistant Experimental Officer, Organic Chemistry, from 31st January, 1956.

Mrs. M. R. Rodgers, Assistant Experimental Officer, Cider and Fruit Juices Section, from 30th June, 1956.

Miss E. Atkinson, Assistant Experimental Officer, Unit of Plant Nutrition, from 25th August, 1956.

Mr. J. H. Scawin, Assistant Experimental Officer, Unit of Plant Nutrition, from 5th October, 1956.

Mrs. A. Harrisson (née Cousin), Assistant Experimental Officer, Cider Microbiology, from 31st October, 1956.

Mrs. E. B. Salway, Assistant (Scientific), Entomology, from 30th April, 1956.

Miss P. M. Hammond, Assistant (Scientific), Cider Microbiology, from 2nd June, 1956.

Mr. L. G. Fish, Assistant (Scientific), Laboratory Assistant, from 31st July, 1956.

Appointments to Administrative Staff.

Miss G. M. Rew, Typist-Telephonist, to succeed Miss A. P. Winters, from 22nd October, 1956.

Resignations : Administrative Staff.

Miss I. Taylor, Library Clerk, from 6th August, 1956.

Miss A. P. Winters, Typist-Telephonist, from 13th October, 1956.

Mrs. B. J. Taylor (née Haysham), Shorthand Typist, from 31st December, 1956.

National Service.

Call-up.

Mr. A. J. Sims, Assistant Experimental Officer, Physical Chemistry, from 1st March, 1956.

Mr. J. S. Challice, Assistant Experimental Officer, Unit of Plant Nutrition, from 6th December, 1956.

Mr. G. Bradshaw, Assistant (Scientific), Cider and Fruit Juices Section, from 4th September, 1956.

Return.

Mr. B. A. Notton, Experimental Officer, Unit of Plant Nutrition, on 15th October, 1956.

Mr. A. H. Fielding, Assistant Experimental Officer, Plant Pathology, on 29th October, 1956.

Mr. D. Aliband, Assistant (Scientific), Entomology, on 15th October, 1956.

Mr. E. W. Spear, Laboratory Attendant, on 15th November, 1956.

Visits Abroad.

Dr. H. G. H. Kearns visited Zanzibar and East African territories on behalf of the Colonial Office during the period 30th January to 7th March, 1956. The special purposes of the visits were to review progress in the control of the *Theraptus* beetle on coconuts in Zanzibar, and in problems of coffee spraying in Tanganyika. He also spent some time in Uganda at the request of the Senior Entomologist of the Government.

Mr. R. W. Marsh spent three months in Yugoslavia, commencing April 1956, on behalf of the Food and Agriculture Organization of the United Nations. The purpose of the visit was to report on the adequacy of the existing services in entomology and plant pathology, and to assist the government of Yugoslavia in planning and organizing an effective pest and disease control service.

Dr. L. C. Luckwill visited Poland for a period of one month in May 1956, at the invitation of the Research Institute of Pomology at Skierniewice, to attend the Scientific Pomology Conference arranged to celebrate the opening of the Institute. The conference was followed by a tour of fruit growing areas of Poland.

Dr. A. Pollard attended the 4th International Congress of Fruit Juice Producers held in Stuttgart from 25th May to 6th June. He contributed two papers on Long Ashton investigations.

Dr. C. Bould attended the 5th International Soil Science Congress held in Paris from 29th August to 8th September, 1956. In addition to contributing a paper on leaf analysis, he read a paper by the Director, who was prevented by illness from attending.

Dr. R. A. Webb visited the Gambia for one month in November to assess the results of his fertilizer field trials there ; these are now in their second year.

Degrees, Honours, etc.

Mr. E. W. Hobbis was awarded the Associateship of Honour of the Royal Horticultural Society in November 1956.

The degree of Ph.D. was awarded to the following during the year :—

Mr. J. G. Carr (Bristol University), for a thesis entitled " The occurrence and role of lactic acid bacteria in cider making."

Mr. G. Somers (Bristol University) for a thesis entitled " Copper fungicide spray deposits."

Mr. D. Wilson (University of Wales) for a thesis entitled " Cytogenetic studies in the genus *Bromus*."

Mr. A. I. Campbell was successful in the N.D.H. Honours examination, and Mr. N. T. Weatheritt in the N.D.H. final examination.

Miss M. E. Holgate gained the Certificate of the Royal Statistical Society in the examination held in March 1956.

Buildings and Land.

The laboratory to accommodate the Spray Analysis section and to provide facilities for the biochemical work of the A.R.C. Unit of Plant Nutrition was taken over from the contractors on 1st June, 1956. Since taking over, special fittings and apparatus have been installed and the laboratories are now all in full use.

The Greenhouse Block, including the header house and special laboratories attached to the greenhouses, was taken over and occupied from 1st September, 1956. A year or so will be needed before this block will be in full working order, as there are many special fittings to be installed and, as many of these are of an experimental nature, progress must be slow. Much of the building is, however, already in use, and much of the greenhouse space will be occupied by experiments in 1957.

Several small building projects mentioned in the 1956 Report have been completed. These include the extension to the farm buildings and erection of lavatories on the north side of the main road, the provision of large sliding doors for the main block of farm sheds, and metal gates to enclose the area occupied by the main block of farm buildings ; a new gateway to provide a suitable entrance to the Station grounds near the new greenhouse block, and the erection of a small building to enclose the oil storage tank near this block ; an acid fume-chamber attached to the sand purification building.

The plans for the proposed new laboratory and office block, and for the canteen building, are still under consideration by the Agricultural Research Council.

The new valuations of the Station buildings under the recent Rating Acts are being dealt with along with other University property. Most of the buildings have already been accepted by the Rating Authorities as Buildings in Charitable Use, and thus eligible for the reliefs obtainable for such property. The actual amounts of relief are still under discussion.

In the plantations the policy of clearing plots no longer needed for experimental purposes has been continued during the year. The main areas cleared comprised Plot 8a, consisting of the apple varieties Allington Pippin and Edward VII, planted from 1919 to 1921, a further section containing apples on Plot 11, which is needed for nursery extension, and one half of the area on Plot 24 planted with gages, dessert plums and a few peaches, all of which have given indifferent fruiting results. Each cleared area will be sown down to grass ley, consisting of Italian rye grass and red clover, to remain for two years before replanting with further tree or bush fruits.

A new plot of perry pears (Plot 25) on the north side of the main road has been established. It consists of 150 trees comprising 50 named varieties considered to be of some vintage and orchard merit. The trees are worked on seedling pear rootstocks, from seeds of the perry pear variety Barnet. Spaces are available in the orchard for the addition of further varieties.

Other Activities.

Members' Day.

The annual Field Day for Members of the National Fruit and Cider Institute was held on 26th July, 1956, on the occasion of the Annual Meetings of the Members and Governors. The main demonstrations concerned methods

of indexing clonal rootstocks for virus infection, systems of planting dessert apples, use of stem builders for plums, methods of management of black-currants, control of fruit drop at harvest time, and designs of spraying machines, including a mist blower for the application of small volumes, a knapsack power mist-blower and a light-weight power sprayer.

Cider Sampling Day.

The annual Cider Sampling Day was held on 3rd May, 1956. The attendance was greater than in many recent years, the 150 visitors filling the milling shed to capacity. On this occasion ciders only were sampled, and these included a wide range made from lesser-known varieties under consideration for inclusion in a new Recommended List. Ciders made by different fermentation treatments and others differing in alcohol content aroused interest and comment. In the afternoon work in progress in the plantations was open to view and some of the experimental work of the Cider Section was demonstrated in the Cider House.

Visitors.

The number of organized parties visiting the Station was only 33, the lowest number to be entertained since 1943. There was a normal number of visitors from overseas, many of whom had been attending the Fifth International Soil Congress in Paris.

Organized Parties, 1956.

Abermule Young Farmers' Club.
Badminton School, Westbury-on-Trym.
Birmingham University, Botany Students.
Bristol 20-40 Club.
Bristol Pharmacy Students' Association.
Bristol University, D.P.H. Students.
Bristol University, Microbiology Class.
British Universities Film Council.
Civil Service Motoring Association.
Colombo Plan Students.
Colston's Girls' School.
Domestic Preservation Courses, Fruit and Vegetables (2).
Duncan House School, Clifton. Science Students.
Fishponds Diocesan Training College.
Gloucester College of Domestic Science.
Halton Old Boys' Society.
Hanham Mothers' Union.
Hereford Training College.
Horticultural Education Association, Branch Annual General Meeting.
Hospital Caterers' Association.
Imperial Forestry Institute, Oxford, Forest Officers.
Institution of Gas Engineers, South-west Section.
Irish Rural Science Instructors.
Manor Farm Allotments Society, Bristol.
Mid-Cheshire Fruit Discussion Group.
N.A.A.S. Entomologists.
N.A.A.S. and L.E.A. Horticultural Officers, Refresher Course.
Nailsworth Secondary Modern School.
Reading University, Horticultural Students.
Redland College.
Southlands Training College, Old Students.
West of England Science Teachers' Association.
Weston-super-Mare Grammar School, Science Students.

Visitors from Overseas, 1956.

Argentine :	Mr. A. delle Coste, Buenos Aires.
	Mr. A. J. R. Jurado, Buenos Aires.
	Mr. R. G. Mallo, Buenos Aires.
Australia :	Dr. H. C. Forster, C.S.I.R.O., Melbourne.
	Mr. R. Nicholls, Skyogle, New South Wales.
	Dr. P. G. Ozanne, C.S.I.R.O., Nedlands, Western Australia.
	Dr. F. Penman, C.S.I.R.O., Victoria.
	Dr. F. J. D. Thomas, Melbourne.
	Dr. M. E. Winfield, C.S.I.R.O., Victoria.
Austria :	Dr. Jos. Schröfl, Vienna.
Belgium :	Mr. R. H. Kips, University of Ghent.
British Honduras :	Mr. S. G. Smith, Belize.
Canada :	Dr. R. S. Lockard, Kaslo, British Columbia.
	Professor N. R. Richards, Guelph, Ontario.
	Dr. P. O. Ripley, Department of Agriculture, Ottawa.
	Dr. J. T. Slykhuis, Lethbridge, Alberta.
	Dr. E. Y. Spencer, London, Ontario.
	Mr. E. J. Trayling, Vancouver, British Columbia.
Chile :	Mr. A. E. Zomosa, Santiago.
China :	Dr. Chen Shan-Ming, Peking.
	Professor Hong Shui-Lwen, Peking.
Cyprus :	Mr. V. D. Krentos, Nicosia.
Denmark :	Mr. I. Groven, Hornum.
	Mr. L. A. Hobolth, Copenhagen.
France :	Dr. R. Heller, Sorbonne, Paris.
Germany :	Dr. H. Bömeke, Jork, Hamburg.
	Dr. W. Büssler, Berlin-Dahlem.
	Miss I. Reuber, Institute for Plant Pathology, Bonn.
	Professor W. Schuphan, Geisenheim.
	Miss G. Splitt, Berlin-Dahlem.
	Miss U. Stockdreher, The University, Bonn.
	Mr. Werner von Stritzky, Hanover.
Gold Coast :	Mr. R. R. Cunningham, W.A.C.R.I., Tafo.
	Mr. R. G. Hurd, W.A.C.R.I., Tafo.
	Mr. J. Lamb, W.A.C.R.I., Tafo.
	Miss E. V. Waller, Agricultural Department.
Holland :	Dr. and Mrs. O. Banga, Wageningen.
	Professor H. A. Leniger, Wageningen.
	Professor and Mrs. F. Logemann, University of Leyden.
	Dr. A. J. P. Oort, Wageningen.
India :	Mr. D. S. Bhander, Patiala, Punjab.
	Mr. K. R. Bhatia, New Delhi.
	Mr. S. K. Bose, Chaubattia.
	Mr. M. V. Dahiphale, Poona.
	Mr. K. B. Deshpande, University of Osmania.
	Mr. L. D. Kapoor, Kashmir.
	Mr. Daya Nand, Lucknow.
	Mr. R. Narasimhan, Coimbatore.
	Professor S. M. Singh, Agra.
Italy :	Mr. G. Peebles, F.A.O., Rome.
Jamaica :	Mr. K. Commissiong, Kingston.
Japan :	Dr. T. Harada, Tokyo.
	Professor Shizuo Kato, Tokyo.
Kenya :	Mr. M. W. Onbaka, Yala.
	Mr. A. Pinkerton, Nairobi.
	Dr. R. W. Rayner, Coffee Research Station, Ruiru.
Malaya :	Mr. Haji Mahmood, Department of Agriculture.
	Dr. G. Owen, Rubber Research Institute.
	Mr. and Mrs. G. F. Stooks, Pehang.
New Zealand :	Mr. J. R. Adams, Auckland.
	Mr. R. G. Hamilton, Department of Agriculture.
	Dr. R. A. Harrison, D.S.I.R., Auckland.
	Mr. P. Lynch, Department of Agriculture.
	Miss A. Taylor, Central Otago.
	Miss J. Watson, Cawthron Institute.
Nigeria :	Mr. M. W. Gibbon, Department of Agriculture, N. Nigeria.
	Mr. J. H. Hinds, Department of Agriculture, Ibadan.

	Mr. H. Irving, Regional Research Station, N. Nigeria.
	Mr. J. L. M. Kowal, Ibadan.
	Mr. and Mrs. T. A. Phillips, Enugu.
	Mr. J. Tuley, Agricultural Department, E. Nigeria.
Norway :	Mrs. T. Nordnes, Stabekk.
	Mr. K. Oland, Vollebekk.
	Dr. A. Sorteberg, Vollebekk.
Nyasaland :	Miss A. Robbins, Zomba.
Pakistan :	Dr. M. A. Islam.
	Mr. N. M. Sial, Tando Jam, W. Pakistan.
Philippines :	Mr. P. S. Subido, Manila.
Poland :	Dr. Z. Borecki, Skierniewice.
Solomon Islands :	Mr. A. H. Green, Pacific Plantations Ltd.
South Africa :	Professor W. F. Barker, Rhodes University, Grahamstown.
	Dr. E. Beyers, Stellenbosch.
	Mr. L. G. Butler, Villiersdorp, C.P.
	Dr. E. R. Orchard, University of Natal, Pietermaritzburg.
	Mr. J. Piaget, Stellenbosch.
	Mr. J. D. H. Reusch, Pietermaritzburg.
	Mr. J. Rijkheer, African Explosives Ltd., Johannesburg.
	Dr. K. H. Schütte, University of Cape Town.
	Mr. R. du Toit, Johannesburg.
Spain :	Professor J. M. Albareda, Madrid.
	Dr. J. M. Busca, Zumanaga.
	Dr. J. R. Villaneuva, Madrid.
Sudan :	Mr. Mustafa A. Ela.
Switzerland :	Dr. H. Gysin, Basle.
Tanganyika :	Mr. J. W. Vail, Dar-es-Salaam.
Thailand :	Mr. and Mrs. Henry Wong, Bangkok.
Trinidad :	Mr. R. F. Barnes, I.C.T.A.
	Dr. G. K. Maliphant, I.C.T.A.
Turkey :	Mr. N. Kaska, Ankara University.
Uganda :	Mr. J. F. Archibald, Coffee Research Unit.
Uruguay :	Mr. A. G. Barbot, Montevideo.
U.S.A. :	Professor J. C. Cain, Geneva, N.Y.
	Dr. E. D. Clark, Minnesota.
	Dr. J. A. Cook, University of California, Davis.
	Dr. J. M. Hamilton, Geneva, N.Y.
	Professor G. B. Heisig, Minneapolis, Minn.
	Mr. G. Lamont, Cornell University.
	Dr. S. E. A. McCallan, Yonkers, N.Y.
	Dr. T. N. Moss, Kellogg Foundation, Michigan.
	Dr. J. A. Naftel, Pacific Coast Borax Company.
	Dr. O. R. Neal, U.S.D.A., Washington, D.C.
	Dr. R. M. Peterson, South Dakota.
	Dr. and Mrs. E. H. Toole, Beltsville.
	Dr. E. H. Tyner, University of Illinois.
	Dr. R. J. Weaver, University of California, Davis.
	Professor and Mrs. J. D. Winter. University of Minnesota.
	Mr. F. T. Winters, Borax Consolidated Ltd.
U.S.S.R. :	Mr. Eugeni Pokhitailo, Omsk.
	Mr. Vadim Zaitsev, Moscow.
Yugoslavia :	Mr. G. Gojkovic, Sombor.
	Dr. Lee M. Hutchins, F.A.O., Belgrade.
	Mr. V. Masten, Ljubljana.
	Mr. D. Vojvodic, Novi Sad.
Zanzibar :	Mr. R. K. Tremlett, Department of Agriculture.

Shows and Demonstrations.

Exhibits were staged at the following shows :—

Bath and West and Southern Counties Society, Cardiff, May 30th–June 2nd.

Royal Horticultural Society, Chelsea, May 22nd–25th.

Bristol Horticultural Show, 29th–31st August.

Scientific Instrument Manufacturers' Association, Bristol, 6th–8th June.

Students and Voluntary Workers.

Dr. Antonia Medina Ortega from the Instituto de Edafologia y Fisiologia Vegetal, Madrid, continued to work with Dr. Nicholas under a scholarship grant from the British Council. Her grant has been extended by the Instituto, Madrid, so that she may complete her work here ; she will probably remain until May 1957.

Miss F. L. C. Blackwall continued her work in the Pomology Section, under a Ministry of Agriculture scholarship until 30th September, 1956, after which the work was supported by the Station. She left at the end of December.

Mr. V. D. Krentos of the Department of Agriculture, Cyprus, worked under Dr. Martin and Dr. Nicholas from May to October, under a grant from the Government of Cyprus. He had spent the first part of his study leave at the Colonial Products Laboratory, Imperial Institute.

Dr. R. Comber continued to work under Dr. Webb until the end of September when he left to take up an appointment as Plant Physiologist in the Gambia.

Dr. W. Büssler of the Institute for Plant Nutrition, Berlin-Dahlem, Germany, spent August and September working in the Unit of Plant Nutrition under Dr. Nicholas and Dr. Webb, whilst holding a travelling scholarship from the Ministry of Agriculture of the German Federal Republic.

Dr. Jos. Schröfl of the Hochschule für Bodenkultur, Vienna, worked under Dr. Nicholas in the Unit of Plant Nutrition during August, at the request of Professor Dr. Kurt Lohwag of Vienna.

Mr. M. W. Case, who holds a Ministry of Agriculture scholarship in horticulture for two years, commenced his studies at Long Ashton on 1st October under Dr. Luckwill and Mr. Hobbis. He has registered for the degree of M.Sc. in Bristol University, and is working on the problem of rosetting of maiden pear trees.

Mr. Werner von Stritzky of Hanover worked under Dr. Kearns on spraying machinery problems between 19th April and 30th June, having come to Bristol under the Bristol/Hanover Scheme.

Mr. K. Commissiong of the Department of Botany, University College of the West Indies, Jamaica, commenced a year of study at the Station under Dr. Nicholas on 3rd October, following a year spent at the Macaulay Research Institute. He is the holder of a Leverhulme Colonial Scholarship for two years.

Mr. R. F. Chudley began his period of six months' training as the holder of the Memorial Studentship in Cidermaking on 1st October. He is a nominee of Devon County Council.

Mr. R. T. Burchill, holder of a research studentship from Durham University, continued his investigations of apple mildew under the direction of Mr. Marsh, whilst working for a higher degree with Dr. Bond in the Horticultural Science Laboratories of the University.

The following students of the Horticultural Science Laboratories worked for a period at Long Ashton whilst studying for the Diploma in Plant Pathology and Protection : Mr. E. C. Hislop, Mr. D. Price and Mr. B. S. Rao.

Social Activities.

The Welfare Committee has been under the Chairmanship of Mr. Lloyd-Jones during the year, and as usual organized the Christmas Party. This took

place on December 20th in W. D. & H. O. Wills' Recreation Hall, Bedminster, as the number of staff and visitors has grown too large for comfort in the Village Hall.

The Christmas Lunch was arranged by the Canteen Committee on the following day, December 21st, when we were very happy to welcome Mr. and Mrs. Spinks as our guests.

Membership of the Tennis Club increased substantially during the year and in consequence the courts were in constant use, particularly at lunch-times. The season was a fairly successful one : of the twelve friendly matches played, seven were won, four lost and one drawn. The Men's team in the Bristol League won four matches and lost six, and so narrowly failed to maintain their position in Group IV.

Rain interfered with several fixtures of the Cricket Club, but eleven matches were played, of which six were won and five lost.

A Table Tennis Club was formed in December. A table has been kindly provided through a grant from the Finance and Business Sub-Committee, and play takes place in the Cider House during the lunch-time break.

The staff spent a very pleasant day at Wellesbourne on June 9th, on a return visit to the National Vegetable Research Station. Last year's results were reversed, Wellesbourne winning the cricket, in spite of a gallant innings of 83 not out by Mr. Burchill, and Long Ashton the tennis. Dr. Martin deputized for the Director on the occasion.

Acknowledgments.

We are indebted to a number of Station staff who have carried out special duties during the year in addition to their normal work, and we are glad of this opportunity of expressing our sincere thanks to them.

Dr. Kearns acted on behalf of the Director during his absence through illness from June to September. He has also continued his assistance in superintending the erection of new buildings and work carried out in the Station workshops, including repairs to equipment, machinery and tools for laboratories and farm. Mr. Spinks continued as Librarian until his retirement at the end of September. Mr. Lloyd-Jones and Mr. Stott served as Chairmen of Welfare and Canteen Committees respectively, and we are grateful to them and to Mrs. Harrisson, Miss Jackson, Miss Goodman and Miss Sturdy for managing the canteen catering during the year.

Our best thanks are also due to all other members of staff for their valued services to the Station during the year, and for the contributions each has made towards the fulfilment of the research programme.

It is a special pleasure to acknowledge the help of our many friends outside the Station, particularly those growers and commercial firms who have assisted us in our work by the provision of gifts of materials and facilities to carry out experiments.

SUMMARY OF RESEARCH, 1956.

Pomology and Plant Breeding.

Plant Breeding.

Three families of black currant seedlings, raised in 1947 with the object of producing late maturing varieties with a high ascorbic acid content, fruited for the first time during 1956, and from a total of 255 seedlings 35 were selected for further observation. Some of these have ascorbic acid contents as high as 250 mg./100 g., though none is exceptionally late in maturing. The collection of *Ribes* species for use in the black currant breeding programme was continued ; the collection now numbers over 100 and work has started on the propagation of this material, prior to testing for disease resistance and other desirable characters.

The first families of cider seedlings, now nine years old, commenced fruiting during the past year, and records were taken of scab and canker resistance, fruit size and quality, and period of harvesting. A few of the most promising seedlings have been selected for propagation and further trial.

Growth Substances.

In view of the promising results obtained in 1955 with NAm (1-naphthaleneacetamide) as a fruit thinning agent for apples, further trials with this substance were conducted during the past year on Miller's Seedling, Laxton's Superb, Lord Lambourne, Crawley Beauty, Worcester Pearmain and Lane's Prince Albert. Thinning was achieved on all varieties but, contrary to the previous year's results, no significant increase in marketable crop resulted from any of the treatments. This difference in response to thinning in the two seasons may be associated with the contrasting weather conditions, 1955 being dry and sunny and 1956 wet and dull. A marked effect of chemical thinning on the biennial cropping of Crawley Beauty has been observed. In 1956, branches which had been moderately thinned with 25 p.p.m. NAm in 1955 carried approximately three times the crop of unthinned control branches (p. 60).

The search for a chemical thinning agent for plums was continued, attention being focused this year on 1-naphthylphthalamic acid, a compound that has been successfully used for thinning peaches. On the varieties Giant Prune and Victoria, however, no significant thinning resulted from treatment with this compound at concentrations of 200 to 400 p.p.m. 8 to 10 days after petal fall, and considerable damage was caused to foliage and extension growth.

An investigation of fruit-set on trees of Cox's Orange Pippin receiving either a lime-sulphur or a captan spray programme revealed well-marked differences. Trees on M.II receiving captan set 28% more fruits per 100 blossom clusters than did comparable trees sprayed with lime-sulphur ; on M.IX the increase was of the order of 60%. The trees sprayed with captan also showed significantly less shedding of fruit-buds (p. 61).

In further trials on the control of pre-harvest drop of apples, NAA (1-naphthalene acetic acid) at 10 p.p.m., and 2:4:5-T (2:4:5-trichlorophenoxyacetic acid) and 2:4:5-TP (2:4:5-trichlorophenoxypropionic acid) at 20 p.p.m. were found to be equally effective on Worcester Pearmain, delaying drop for a period of two to three weeks. The same treatments were without effect on

Cox's Orange Pippin. Following laboratory tests with *Coleus* petioles in which synergism between NAA and the anti-auxin *trans*-cinnamic acid was found, the effects of these compounds, alone and in combination, in controlling fruit drop were investigated. In the field, however, no synergistic effects were observed.

NAA at 10 p.p.m. applied to black currants (*var.* Mendip Cross) four days before the normal harvest date, with the object of preventing berry drop, had little effect on crop weight or quality. At 25 p.p.m. the spray resulted in a marked stimulation of ripening which was reflected in a higher percentage of burst berries and a lower ascorbic acid content of the juice (p. 66).

Further attempts were made to stimulate parthenocarpic development of apples and pears by treating emasculated blossoms with various growth substances in combination with coconut-milk extracts. The latter are known to be a rich source of growth factors that are required, in addition to auxins, for the growth of certain tissues, but none of the eighteen treatments used in this experiment proved effective in stimulating fruit development.

In an experiment designed to investigate the effect of one fruitlet on the abscission of other fruitlets on the same cluster, no evidence for the production of an abscission-promoting hormone, such as has recently been demonstrated in leaves, was found.

The sensitivity of different fruit plants to various phenoxyacetic acids and their corresponding butyric homologues was investigated. Black currants were found to show a high degree of tolerance to 2:4:5-trichlorophenoxybutyric acid, suggesting that this compound may prove of value for the control of some perennial weeds (particularly Bindweed) in black currant plantations. In exploratory trials with a range of selective and pre-emergence herbicides in fruit nursery crops 2:4-dichlorophenoxy-ethyl sulphate at rates of 2 to 4 lb./100 gallons/acre gave excellent weed control in apple and quince stoolbeds, and in cutting- and layer-beds of plums, cherries and loganberries. The same herbicide also gave complete control of Groundsel and *Poa annua* over a period of ten to twelve weeks in nursery beds of black currant. A report on this work was presented at the British Weed Control Conference in November (24).*

Variety Trials and Cultural Experiments.

The experiment on the growth and cropping of apple trees in relation to planting system, now in its ninth year, produced the heaviest crops to date. The crops for Cox's Orange Pippin in bushels per acre were : cordons, 250 ; dwarf pyramids, 550 ; bush trees on M.IX, 200 ; bush trees on M.II, 250. Fruit size was satisfactory for Cox and Laxton's Superb, but was disappointing for Winston, fruits of which were undersized on trees on M.IX and more so on trees on M.II.

Crops from the gages (Oullin's Golden, Cambridge, Denniston's Superb and Comte d'Althan) were again unsatisfactory owing to loss of ripe fruits from splitting, which was particularly severe during the wet summer of 1956. Splitting was much less severe on culinary plum varieties and the variety Marjorie's Seedling was again outstanding, few split fruits being noted in spite of a very late picking season. On the experimental peach plot Rochester was again the only variety to yield an appreciable crop.

* See *Publications*, 1956, pp. 177–180.

Rootstocks and Propagation.

During the past year numerous reports of the failure of maiden pears budded on Quince A stocks have been received and an investigation has been started to discover the cause of this trouble, of which the most pronounced symptom is a rosetting of the maiden growth (p. 51). At Long Ashton the variety Conference and the perry varieties Blakeney Red and Aylton Red are severely affected, whilst in commercial nurseries similar symptoms have been seen on Conference, Pitmaston Duchess, Emile d'Heyst and other varieties. There is some evidence that quince stocks from different sources give different proportions of diseased and healthy trees, but as yet there is no definite indication that a virus is the causal agent.

Observations on commercial varieties of apple worked on the two apomictic seedling stocks *Malus toringoides* and *M. sikkimensis* have been continued. Small trials to investigate the performance of these stocks have been planted at Long Ashton and at a site in Herefordshire. Experiments with *M. toringoides* have shown that this species will form fruits and set seed without the need for pollination, and a cytological investigation of the mechanism of seed formation is being carried out.

A third apomictic apple species, *M. theifera*, has proved completely graft-incompatible with commercial apple varieties. In an experiment completed this year it has been shown that this incompatibility is of an unusual type, in that it can be transmitted through a mutually compatible interstock of *M. toringoides*, *M. sikkimensis* or *M. Tschonoskii*. The nature of the incompatibility is being further investigated.

Rooting experiments with hardwood cuttings of the plum rootstock Brompton showed that cuttings taken during September rooted much better than those taken between October and February. Treatment of cuttings with 2:4:5-trichlorophenoxyacetic acid or with indolebutyric acid, at concentrations of 1,000 to 5,000 p.p.m., by the concentrated-dip method, failed to improve rooting.

Cider and Perry Varieties.

Work on the revised " Recommended List of Cider Varieties for General Planting " was completed in collaboration with a sub-committee of the Cider Advisory Committee. The revised list is published in the present report (p. 44). Following a request from the same committee a list of perry pears suitable for planting has been prepared and is also published in this report (p. 48).

The survey of perry pear varieties in Herefordshire, which it was hoped to complete in 1956, had to be discontinued owing to widespread outbreaks of foot-and-mouth disease in that county which prevented the necessary visits to farms. Work on the description of perry pear and cider apple varieties was continued.

Many of the bush cider trial plots planted in 1951–53 yielded their first appreciable crops in 1956 and samples for small-scale cider-making tests were collected.

A number of single-variety cider orchards have been selected for use in pollination studies. In one orchard of the triploid variety Bulmer's Norman, fruit set and seed development were good, even in the complete absence of

pollinators, and the possibility of apomixis is being investigated. In another orchard the optimum spacing of pollinators is being investigated by recording fruit set and seed content at different distances from pollen sources. The maximum effective distance of the pollinators in 1956 was approximately 90 ft., but this may be expected to vary somewhat from season to season.

Plant Nutrition: Fruit.

Field Experiments.

During 1956 there were some striking differences in the growth and leaf nutrient status of the young apples in the cover-crop trial at Long Ashton (Plot 18). Compared with clean cultivation, the covers markedly depressed tree vigour and leaf nitrogen status, their effect increasing in the order: clover < " tumble-down " (natural sward) < timothy < perennial rye grass (p. 76). On the rye and timothy plots additional fertilizer nitrogen was without effect on the vigour of the trees or on the nitrogen content of the leaves.

A detailed botanical count on the plots of this experiment was carried out under the supervision of Dr. Luckwill. The results indicated that the main species, i.e. white clover, perennial rye grass and timothy, were well established. On " tumble-down " plots *Poa annua* was the dominant species, with a fair proportion of *Agrostis stolonifera*. *Poa annua* was a serious weed on all plots. Fertilizer treatments applied in the spring had no effect on the botanical composition of the swards as determined in the following August.

The young trees in the apple-cover crop-manurial experiment at Efford N.A.A.S. Experimental Horticulture Station suffered some damage from airborne salt but they recovered later in the season. Surface water-logging occurred in one block during the winter but this condition has been remedied by tile drainage.

The plum trees in the cover crop-manurial experiment at Luddington N.A.A.S. Experimental Horticulture Station continue to make satisfactory growth.

Field work with iron chelates was continued in the Evesham area. Satisfactory seasonal control of lime-induced chlorosis in pears was obtained by sub-soil injection of 20 g. Fe per tree, as Ferro-Versenol (Fe-HEEDTA (hydroxyethylethylenediamine tri-acetic acid)), and by several consecutive foliar sprays of this chelate at 0·1% concentration. Preliminary experiments were also made with the comparatively new iron chelates of CDTA (cyclohexanediamine tetra-acetic acid) and of Chel-138.

The first crop was taken from the new strawberry nutrition plot at Efford. Contrary to the field results at Long Ashton, there was a significant positive yield response (at 5% level only) to superphosphate applied at 4 cwt. per acre, but no significant response to nitrogenous or potassic fertilizers at any level. Until the leaf samples have been analysed interpretation of these conflicting results is difficult. At Long Ashton the phosphorus status of plants on the phosphate-deficient plots remained well above the threshold level; hence the failure to respond to fertilizer phosphate.

Further experiments with strawberry *var.* Royal Sovereign, on the long-term deficiency plots at Long Ashton, confirmed the importance of potassic fertilizers for this crop and the value of leaf analysis for assessing its phosphate requirement (p. 84).

A new experiment, using two varieties, Royal Sovereign and Talisman, was started on the long-term deficiency plots at Long Ashton to gain further information on the relationship between fertilizer treatment, leaf nutrient status and crop yield.

Data on shoot growth and crop yield in relation to manurial treatment were collected, on a plot basis, from the black currant manurial experiments at Efford and Luddington, together with leaf samples for chemical analysis. The growth of bushes was fairly satisfactory at Efford, but there were indications that soil water supply may become a limiting factor at Luddington.

Similar data were taken on a bush basis from the black currant nutrition experiment at Long Ashton, with a view to correlating leaf nutrient status, plant growth and crop yield. Attempts will be made later to regulate the nitrogen status of these bushes by soil applications of fertilizer and by foliar sprays.

Pot culture.

Preliminary trials were made using mist, water and sand culture methods for growing a range of fruit crops. Temperature control of the rooting medium appears to be more critical for mist and water than for sand culture. Apple trees on M.VII rootstock made satisfactory growth in mist and water culture and they appeared to be more tolerant to high temperatures than trees on M.II rootstock.

A sand culture experiment was started in the autumn to study the phosphorus nutrition of strawberry, *var.* Talisman, using four levels of phosphorus, two levels of nitrogen and adequate levels of all other nutrients.

Preliminary experiments on tomatoes, using polyamine-polyacetate chelating agents as a source of nitrogen, indicated that the nitrogen from these compounds can be metabolised to some extent but much less efficiently than corresponding levels of nitrogen supplied as nitrate.

Laboratory Investigations.

A large number of leaf samples were analysed during the year in the long-term investigations on the relationship between leaf nutrient status and crop performance.

An improved formaldoxime method for the determination of manganese in plant material has been developed. Interference from iron and copper is eliminated by warming the solution, which results in the decomposition of the formaldoxime complexes of these metals, and precipitation of metal phosphates is prevented by using N-hydroxyethylethylenediamine tri-acetate. The method is as rapid as the periodate procedure and its sensitivity is about five times as great.

Preliminary investigations were made on methods for determining the cation exchange capacity of roots.

In collaboration with the Chemistry Section, further experiments were made to determine the extent of isotopic exchange of ^{32}P in an acid, high phosphate-fixing soil. In work with ^{59}Fe-labelled chelates in soils it was shown that a considerable amount of isotopic exchange occurred if the chelating agent were HEEDTA or DTPA (diethylenetriamine penta-acetic acid) but little or no isotopic exchange occurred with the iron chelates of CDTA or Chel-138.

The spectrophotometric method of analysis was extended to three more chelating agents, CDTA, Chel-138 and HEEDDA (dihydroxyethylethylenediamine diacetic acid).

Further studies were made on the behaviour of iron chelates in calcareous soils and pure clays. Chel-138-Fe and Fe-CDTA were sorbed to only a slight extent, and little precipitation of iron took place from these chelates; Fe-DTPA and Fe-HEEDDA lost considerable amounts of iron by sorption and precipitation. Preliminary experiments with pure clays indicated that the sorption of iron chelates varies with the chelating agent, the type of clay, the pH of the solution and the nature of other ions present.

Chemistry.

Organic Chemistry.

In further investigations of the relationship between the molecular structure of plant growth regulators and their biological activity, the synthesis of substituted 2-naphthyloxyacetic acids has been continued. The importance of substitution in the 3-position has already been stressed (Report for 1955); three further acids, the 3-methoxy, 3-bromo and 3-fluoro derivatives have been prepared, and the synthesis of the 3-methyl and 3-nitro compounds is in progress. The fluoro compound was obtained from 3-fluoro-2-naphthol, a substance not hitherto prepared. Members of three other series of acids, the 5:6:7:8-tetrahydro-2-naphthyl-, 2-naphthylamino- and 2-thionaphthyloxy-n-alkyl carboxylic acids have been prepared but have not yet been tested for their growth regulating activity. Attempts to prepare 1-hydroxy-2-naphthyloxy acetic acid are continuing; this substance is of interest not only because of its potentiality as a growth regulator but also because it is a metabolic product of *Aspergillus niger* when the parent acid is included in the substrate.

In tests of fungistatic activity 3-fluoro, 3-chloro and 3-bromo-2-naphthols, ac- and ar-tetralols, and 3-nitro-5:6:7:8-tetrahydro-2-naphthol have been compared with 2-naphthol in mycelial growth-inhibition tests using *Sclerotinia laxa*. All except ac-tetralol showed greater activity at 10^{-4} M than 2-naphthol. A series of sulphur-containing acids, 2-thionaphthyloxy acetic, propionic and n-butyric acids, was also tested for fungistatic activity against *S. laxa*. The first two of these compounds caused a significant reduction in growth; at a concentration of 10^{-4} M the propionic acid was the more effective.

Further derivatives of 8-hydroxyquinoline (" oxine ") have been prepared in connection with a study of its mode of action. The fungistatic properties of the series of 5-n-alkyloxines previously reported (Report for 1955) have now been examined; the activity was found to rise to a maximum at a chain length of 5 or 6 carbon atoms. A preliminary report on the effect of the addition of metals and a second chelating agent, such as ethylene diamine tetra-acetic acid, on this activity, has been submitted to *Nature*.

Work on the metabolism of ω-(2-naphthyloxy)-n-alkyl carboxylic acids by *Aspergillus niger* has been completed and published (10). In this work it was shown by means of a replacement culture technique that the acids $C_{10}H_7O(CH_2)_nCOOH$ (where n=4–9) undergo nuclear hydroxylation, with subsequent β-oxidation to 6-hydroxy-2-naphthyloxy acetic or β-(6-hydroxy-2-naphthyloxy)

propionic acids in the odd and even series respectively. Similar results have now been obtained with the corresponding phenoxy acids $C_6H_5O\ (CH_2)_n\ COOH$ (n = 1–4). Phenoxy acetic and β-phenoxy propionic acids were hydroxylated in the *para* and, to a lesser extent, the *ortho* positions, both products being less toxic to the fungus than the parent acids. γ-Phenoxy-n-butyric acid likewise gave mainly *p*-hydroxyphenoxy acetic acid by hydroxylation and β-oxidation, but δ-phenoxy-n-valeric acid gave a mixture of *o*- and *p*-hydroxy-β-phenoxy-propionic acids. This resistance of the side-chain to further oxidation has already been noted with the corresponding β-(6-hydroxy-2-naphthyloxy)-propionic acid and contrasts sharply with the known conversion of β-phenoxy-propionic acid to phenol in the flax plant. Current work aims at further investigation of this apparent anomaly.

Physical Chemistry.

Work with radioactive tracers, involving the use of ^{32}P, ^{59}Fe and ^{99}Mo, has continued in collaboration with other Sections, and work with ^{14}C assays has begun. With the Fruit Nutrition Section, laboratory studies were made of the behaviour of four additional iron chelates in calcareous soils, using materials labelled with ^{59}Fe (see Fruit Nutrition, p. 25). Examination of the isotopic exchange of ^{32}P between added fertilizer and soil phosphate has been continued, using a second soil low in phosphate and of high phosphate-fixing properties. The results confirm that in this soil ^{32}P assays provide a reliable measure of fertilizer phosphate uptake. In collaboration with the A.R.C. Unit experiments have been carried out with ^{59}Fe and ^{99}Mo to investigate the distribution of iron and molybdenum in protein fractions of *Azotobacter* and *Neurospora*.

Work has commenced on the factors influencing the disintegration of a fluid jet as it leaves the spraying orifice. An experimental technique, using the vibrating jet method, has been developed for the determination of the rate at which freshly formed air-liquid interfaces attain their equilibrium surface tension values, and its reliability is being assessed using pure liquids of known surface tension.

Further investigation has been made of the influence of wetting agents, of anionic, cationic and non-ionic type, on the retention of copper fungicide sprays applied to leaf surfaces to beyond the " run-off " stage. The amounts of deposit retained were only slightly reduced by polyethenoxy surface-active agents, whereas some wetting agents of anionic type gave an exceptional reduction at concentrations greater than the critical concentration for micelle formation. A study has been made of the factors influencing the deterioration of Burgundy mixture to malachite ; continuous stirring has been found to have an important retarding effect. The best method of preparing a standard Bordeaux mixture with respect to its tenacity, fungitoxicity and suspending powers has also been investigated. Field experiments on the use of polyvinyl-acetate-cuprous oxide formulations for the control of potato blight and apple canker, made in collaboration with the Plant Pathology Section, have shown that the use of the resin supplement does not give any marked improvement in the control of the diseases.

Analytical and General Chemistry.

The development of methods for the characterization of insecticide and fungicide spray deposits has continued. Nitro-cellulose in ethyl acetate has been used to recover deposits of copper fungicides from leaf surfaces, and DDT deposits have been picked up from sprayed surfaces using a water-soluble synthetic resin adhesive. The transparent films carrying the deposits are mounted on microscope slides for detailed examination.

In the chemical assessment of deposits, particular attention has been given to micro methods for the determination of spray materials on small areas of plant surface. Rapid micro methods have been developed for DDT and sulphur fungicides (pp. 127 and 122). The micro method for the determination of copper described in the Report for 1955 has been improved to overcome sensitivity to ammonia concentration and pH ; the use of oxalyldihydrazone in this method provides a more sensitive test but otherwise confers no great advantage over the *cyclo*hexanone derivative. Work has commenced on the micro determination of mercury deposits.

A method has been developed for chlorobenzilate deposits (p. 130) and attention has been given to the determination of DDT and chlorobenzilate occurring together on plant surfaces. The study of the chemistry of dieldrin was continued with a view to obtaining a suitable method for deposits.

In field work with the Entomology and Plant Pathology Sections to assess the efficiency of spray materials and the performance of spraying equipment, toluene and naphtha emulsions of DDT and chlorbenside were found to give deposits comparable with those from the benzene emulsions used in the Long Ashton spring washes. DDT deposits were determined on apple and pear fruits and foliage in the comparison of the efficiencies of hand, automatic hydraulic and mist-blower applications, and measurements were made of the levels and distribution of deposits of copper fungicide from large and small droplets on pear trees. Captan deposits were determined in spraying trials on gooseberries and strawberries, and on Allington apples used for testing the control of *Gloeosporium* rots in storage (p. 113).

The formulation of the spray material and the nature of the surface treated have been found to influence the deposit obtained. Different deposits of a copper fungicide were obtained on the upper and lower surfaces of black currant leaves ; the addition of wetter improved distribution but lowered the level of the deposit on the under surface. The incorporation of a wetter in a full-coverage lime sulphur spray also improved distribution but reduced the deposit. The method of analysis developed for chlorobenzilate was used to determine the levels of deposits accumulating in the axils of black currant leaves after treatment with different formulations. The effects obtained focused attention on plant waxes, and work on the characterization of these was commenced.

Collaboration has continued in spraying trials undertaken by the Entomology Section in countries overseas. A final trial in 1956, involving many analyses and distribution studies, completed the work on the control of the Leaf spot disease of banana in the West Indies. Analytical work was carried out on banana and coffee foliage samples from East Africa. Determinations of DDT were made on coconut spadices and foliage from spraying trials also in East Africa.

Work in conjunction with the Plant Pathology Section and the A.R.C. Unit on the effect of fungicides on fungus enzyme systems has continued. An examination of the effects of captan, copper, sulphur and *o*-phenyl phenol on enzymes of *Sclerotinia laxa* has been extended to enzymes of *Botrytis cinerea* (see Plant Pathology, p. 33).

In collaborative work with other organizations, tar oil components were formulated and sent to the National Vegetable Research Station for test as fungicides ; analyses were made for DDT in soil, for the same Station ; potato leaves submitted by the N.A.A.S. were examined for copper deposits, and work was carried out with the Infestation Division of the Ministry of Agriculture, Fisheries and Food on the determination of DDT and BHC in grain, using the macro method published in the Report for 1955.

Entomology.

Biology of insect pests.

Observations of seasonal fluctuations in the intensity of attack by fruit aphides, of importance in timing the application of spring sprays, have been continued. Whereas in 1955 very little damage resulted from severe infestations of Oat Apple aphid (*Rhopalosiphum insertum*), a small population of Rosy Leaf aphid (*Sappaphis plantaginea*) in 1956 caused severe distortion of the leaves and fruits of some varieties of apple, particularly Bramley's Seedling. Hatching of the currant aphides has been found to vary greatly from season to season in relation to the stage of bud development : a late hatch combined with early bud development adds greatly to the difficulty of control by spring washes.

A study is being made of the life histories of the fruit tree leaf hoppers, which have increased considerably during the last few years and are now present in sufficient number to cause damage to the foliage of apples and plums.

A method whereby enlarged images of transparent cellulose acetate impressions of infested leaves are projected on a screen (see Report for 1955) has proved helpful in the rapid assessment of Red Spider infestations.

Bio-assays of insecticides and fungicides.

Studies of the effects of insecticides on the respiration and on the muscle and nerve tissues of adult insects have been continued. With adult males of the migratory locust (*Locusta migratoria migratorioides*) the insecticidal activity of paraoxon was found significantly greater than that of all other nitrophenyl-phosphorus compounds tested. This may be attributed to the direct action of the compound, involving no change from inactive to active form *in vivo*, and also to a better translocation of the compound from the point of application to the site of action. The toxicity of injected paraoxon was of the same order as that topically applied. Parathion, its isomers, and ethyl *p*-nitrophenyl phenyl phosphonothionate (EPN) were approximately equivalent whereas malathion, although relatively low in toxicity, with an ED_{50} of 29 μg./insect, was still a reasonably effective insecticide. Methyl, ethyl and *iso*-propyl esters were effective in descending order of toxicity : substitution of other alkyloxy or aryloxy groups resulted in loss of activity (54).

The *in vitro* activities of the cholinesterase and acetylesterase of the migratory locust and the grain weevil (*Calandra granaria*) have been examined. There appear to be two distinct enzymes present ; in both insects their activities are at comparable levels and their inhibition by the organophosphorus compounds examined is also similar ; compounds possessing the phosphoryl group have high inhibitory activity and those with the thiophosphoryl group have low activity *in vitro* (55.)

Spray Techniques.

The study of the fundamental effects produced by the incorporation of surface-active agents as spray supplements has been continued. An initial survey of the phytotoxicity of several types of wetting agents on fruit tree foliage was carried out. Preliminary results indicate that phytotoxicity varies considerably with both the chemical structure of the wetting agent and the nature of the leaf surface ; the toxicity of anionic agents is much greater than that of cationic agents on apple leaves, whereas with plum leaves the opposite is the case. A laboratory study of surface-active agent " leaf reactions " has been commenced which may be of value in explaining variations in the results. Many reactions are possible in these systems, but the most important appears to be a complex formation between the surface-active ions and the long carbon-chain alcohols that are present in leaf waxes. The formation of these complexes on the leaf surface modifies the action of the surface-active agent and may affect the levels, distribution and phytotoxicity of the spray application.

The movement of droplets on solid surfaces has been studied from electronic flash photographs of single droplets. Dynamic advancing and receding contact angles can be measured directly from these photographs, but for more accurate measurements it may be possible to develop a mathematical derivation of the contact angles from the profile curve of the droplet. Multiple image photographs, using a high intensity stroboscope as light source, have been used to study the impaction and rates of movement of droplets on waxed glass surfaces.

A vibrating reed sprayer is under development for laboratory studies on the production and impaction of spray droplets. This equipment provides a means of delivering a single stream of perfectly uniform droplets at a constant rate.

Laboratory experiments on the behaviour of spray deposits were continued, using *Botrytis fabae* as the test organism. A simple suction apparatus for the uniform distribution of dry spores on leaves and other surfaces was developed. The spores were able to develop in a relative humidity as low as 70 per cent. on an apparently dry leaf surface but not on an artificial one ; free water on a leaf surface increased the range of action of a fungicide beyond the site of deposition ; some fungicidal deposits were lethal to fungus spores separated by a thin dialysing membrane. In view of the need for information on moisture levels on leaf surfaces, methods of determination are under investigation. Transparent impressions on cellulose acetate film (see Report for 1955) were used for assessing percentage germination of spores, percentage cover and range of action of fungicides on leaves. Leaf expansion in relation to the distribution of fungicides was also determined.

The levels and distribution of spray deposits due to different conditions of application were determined. Small-volume applications of a copper fungicide to apples and pears by means of a mist blower showed no significant difference in deposit levels between two droplet size ranges applied under the same conditions. Experiments with the precision siting of DDT and BHC emulsions at the green-cluster stage of apples showed that BHC was superior to DDT for the control of aphis ; the addition of a succinate wetter improved the performance of the DDT but made little difference to that of the BHC. It was found that apple foliage sprayed with 0·025 per cent. DDT, as a benzol emulsion, remained toxic to the larvae of the Winter Moth (*Operophtera brumata*) over a period of 17 days.

The Chemistry Section has completed the analysis of a large number of leaf samples collected during trials of copper fungicides for the control of Leaf Spot on Lacatan bananas in Jamaica (Report for 1955). Bordeaux mixture, used in conjunction with 0·025 per cent. of an alkyl aryl polyether alcohol wetter, gave full coverage and satisfactory distribution and retention ; deposits of 8 and 4 μg. copper per sq. cm. were obtained from sprays containing 0·2 and 0·1 per cent. copper respectively (p. 135). Similar trials of copper fungicides, made in Tanganyika in 1956 for the control of *Hemeleia* Rust on *Arabica* coffee, and for " tonic " spraying, gave very different results and showed the need to select the type and concentration of wetter very carefully for each kind of foliage. More experiments are needed with banana and coffee leaves, particularly to find the influence of particle size on spray retention.

Spray materials were prepared for experiments in the Solomon Islands on the control of the *Amblypelta* Nutfall Bug of coconuts ; for work in Uganda on the *Lygus* bug of cotton, and for experiments on the control of the aphid vector of Bunchy Top virus of hemp in North Borneo.

Spray Machinery

A visit was made to Zanzibar in connection with the use of the experimental mist-blower sprayer and observation ladder, described in the Report for 1955, in experiments on the control of *Pseudotheraptus* Nutfall Bug of coconuts ; a number of field trials were needed to obtain the necessary correlations between droplet sizes and kill of the insect. A small air compressor and ancillary equipment were supplied for experimental work on coconuts in the Solomon Islands. Specifications were prepared for spray machinery suitable for the spraying of coffee plantations at the Research Station, Lyamungu, Tanganyika, and for machines for the experimental spraying of citrus in Jamaica.

Several small-power 70 c.c. I.C. spray machines were made to suit special requirements of the National Agricultural Advisory Service and of Research Stations. In testing the performance of a 50 c.c. 2-stroke I.C. knapsack mist sprayer it was found that the percentage of droplets in the 50–150 micron range increased with air velocity (p. 147). The factors involved in the air shear of liquids are under investigation.

The Long Ashton $\frac{1}{4}$″ B.S.P. swirl nozzle was improved by the development of new discs which gave better carry and increased its value for automatic spraying, and by fitting better filters and an easy-clean type of holder for the ceramic inserts for fan sprays (p. 157). Several designs of light-weight spray lances were made for greenhouse spraying, for selective weed killers and for mushroom beds.

Plant Pathology.

Evidence was obtained indicating that the resistance to brown rot (*Sclerotinia fructigena*) shown by bittersweet cider apples (6) arose from the inhibition of the fungal pectolytic enzymes by oxidised polyphenols present in high concentration in the resistant varieties. Other compounds related to phenols occurring in fruit trees were tested as inhibitors of spore germination of *S. fructigena*.

Marked changes in the enzyme patterns of *S. laxa* and *Botrytis cinerea* were shown in cultures grown in the presence of the fungicides lime sulphur, copper sulphate, captan and *o*-hydroxydiphenyl (11). Griseofulvin (0·1% active content) gave some reduction in infection by *S. fructigena* of wounds in maturing apple fruits : on mummied fruits three antibiotics and three substituted *bis*-phenols showed little promise of inhibition of sporulation.

The light requirement for sporulation in *S. laxa* was found to be less than that for *S. fructigena* ; dissemination of spores in the orchard was effected by bluebottle flies as well as by wasps.

Overwintered apple leaves that had been infected in Autumn 1955 with conidia of *Gloeosporium perennans* produced an ascus stage in June 1956. The identity and pathogenicity of this material are being examined.

Morphological studies of shoot cankers caused by *G. perennans* showed that the fungus spreads during winter in the fibres, sieve tubes and wood vessels. In late spring and summer the spread is checked by gumming and cork barriers, but cankers initiated in 1953–4 continued to sporulate up to 1956. A paint of 0·3% phenyl mercury chloride in polyvinyl acetate emulsion applied to sporing cankers in July reduced spore output in the following 2 months by 85% compared with the controls.

Allington apples sprayed on the tree in 1955 with 0·1% captan on : (a) 20 August and 17 September ; (b) 17 September ; showed 1% and 4% storage rots respectively in February 1956, compared with 7% on the unsprayed controls. In 1956 the spray treatments were applied in : (a) July, August and September ; (b) August and September ; (c) September ; the respective captan residues per fruit on 16 October were : 2·2, 0·65 and 0·34 p.p.m. After 4 months' storage at 37°F. the percentages of apples with *Gloeosporium* rots were, respectively : (a) 1 ; (b) 2 ; (c) 4·5, compared with 7% on unsprayed fruit (p. 109).

Studies on apple mildew have shown that overwintering bud infections can be initiated only in the early stage of bud development, before the scales close together. Field trials with successive lime sulphur applications demonstrated that a green-cluster spray at 1% was ineffective against mildew. In another trial on Cox's O.P., a three-year programme of post-blossom captan following pre-blossom lime sulphur has resulted in extensive late-summer leaf mildew but negligible bud infection (p. 103).

In a continuation of the gooseberry mildew control experiment at Luddington, the comparable crop weights following spraying treatments were : zineb 55 lb. ; Karathane 37 lb. ; soda-soap 19·6 lb. Mildew occurred only on the zineb-sprayed plots. At Long Ashton, zineb, Karathane and captan sprays were applied to Leveller gooseberries on 20 April and 17 June. The captan deposit on the fruits was 0·43 p.p.m. on 20 June. In tasting trials of fresh, canned and frozen fruit from the sprayed plots the majority of the tasters recorded no taints.

In the strawberry spraying experiment at Luddington infection with *Botrytis* was negligible in 1956. At picking, the captan residues following 4, 3, 2 and 1 sprayings respectively were 5·6, 2·1, 0·8 and 0·8 p.p.m. : on fruits dusted four times with captan the residue was 3·4 p.p.m. In the tasting trials the over-all preference was for the unsprayed samples, but there was no consistent relation between the residue figures and the recording of taints in the fresh and the processed fruit.

The plots comparing high-worked with low-worked plums (Czar, Victoria and Giant Prune) at Long Ashton have shown seven deaths from bacterial canker in the low-worked trees : one in the high-worked. Yields have not been reduced by high-working.

In collaboration with the Chemistry Section, studies were continued on the metabolism of ω-(2-naphthyloxy)-alkyl carboxylic acids by fungi (10). Nuclear hydroxylation in the 6-position by *Aspergillus niger* may be zinc-dependent. In 2-methoxy-naphthalene (nerolin), ring fission takes place rather than hydroxylation : attempts to identify the principal metabolite are proceeding. Routine tests of fungistatic activity were made on the compounds produced. Other tests, on a series of 5-alkyl-8-hydroxyquinolines, showed differences in fungitoxicity between the unchelated molecules and the metal chelates. For example, 8-hydroxyquinoline was less active than its copper complex but 5-amyl-8-hydroxyquinoline was more fungistatic than the corresponding copper chelate.

Cider and Fruit Juices.

Cider and Perry.

A new list of Cider Apple Varieties Recommended for Planting has been prepared by the N.A.A.S. and the Station Orcharding Committee and is published in this Report (p. 44). Vintage trials of other varieties that may be suitable for later inclusion in the list are being continued.

Work on the composition of juices, ciders and perries has, in the past year, been concerned mainly with nitrogenous components and organic acids. An amino acid not previously reported in natural products has been found as a main nitrogenous constituent in many perry pear juices and in perries : in ciders it is present only in traces. It has been shown to be 1-aminocyclopropane-1-carboxylic acid. The earlier work on amino acids has been prepared for publication : later work on the effects of yeast autolysis in ciders on their content of amino acids and on their susceptibility to bacterial attack is described in this Report (p. 162).

Further work on the organic acids in juices has shown that, in addition to the main components malic and quinic acids, cider apples contain traces of shikimic acid and larger amounts of citramalic acid. In cider fermentations both quinic acid and shikimic acid are reduced to dihydroshikimic acid by certain lactic acid bacteria ; citramalic acid appears unchanged. The bacteria also hydrolyse the chlorogenic acid present in juices and metabolise the caffeic acid portion of the molecule.

The practice of sulphiting juices to encourage the growth of the main fermenting yeasts, now more widely adopted by the industry, is of chief value in the fermentation of low-acid juices. Recent work has shown that the relative numbers of fermenting and non-fermenting yeasts, and of bacteria, surviving sulphiting are dependent upon the juice pH. Subsequent changes in acidity,

dependent upon the balance between these types of organism, are thus in turn dependent upon the initial pH of the juice. The fate of selected yeasts added to a sulphited juice is again dependent upon pH : the higher the pH the greater is the proportion of the initial juice flora that persists through the fermentation. The use of selected wine yeast strains in cider fermentations has been found to offer no advantage over the use of the naturally occurring fermenting yeasts selected by sulphite treatment.

The classification of the yeasts and lactic acid bacteria isolated from fruit, juices and ciders is now well advanced and much of the work on bacteria has been prepared for publication. Several new yeast species have been isolated and problems of classification raised by this work have been discussed (1). The metabolic activities of both yeasts and bacteria are being further investigated and related to the role of the organisms in fermentations. Work on the acetic bacteria is now in progress and is linked with the study of problems associated with the production of cider vinegar.

Unfermented juice products.

The effects of delayed harvesting of black currants on the chemical composition of the fruit are described in this Report (p. 66). The composition of black currants and of other commonly grown soft fruits has been studied in greater detail. They show a wide range in nitrogen content but a similar amino acid pattern. Malic and citric acids are dominant in most fruits but shikimic acid is a main component of the acids in gooseberries. Blackberries contain, in addition to malic acid, iso-citric acid and its lactone and small amounts of quinic and shikimic acids.

A study of the phenolic components of black currants, important in relation to ascorbic acid stability, has shown the presence of a substance tentatively identified as esculetin.

The preparation of juices and concentrates has continued. Black currant juices bottled in diluted form for direct consumption, a type popular abroad, have been made for demonstration purposes. The use of low concentrations of sulphur dioxide as an antioxidant in the extraction of strawberry juice has been found to delay deterioration. Further work on concentrated juices has confirmed the importance of low storage temperatures if loss of colour and of ascorbic acid and adverse flavour changes are to be avoided. Storage in the presence of sulphur dioxide retarded deterioration in raspberry and black currant concentrates at higher temperatures but had a slightly adverse effect upon the flavour of the former.

The investigation of the ionic state of copper in fruit juice systems has been continued, with quantitative measurements of the complexing of copper with fruit constituents. Earlier work on organic acid and amino acid complexes and on the behaviour of copper in promoting the formation of storage hazes in juices has been prepared for publication. Later work has been concerned with a more detailed study of the reactions of juice phenolics. The oxidation-reduction potentials of chlorogenic acid, caffeic acid and catechin have been determined by polarographic methods. The extent of complexing of these compounds with copper has been studied, mainly by potentiometric methods, and equations relating the amounts of the various ionic species have been derived. At the pH of fruit juices copper is mainly complexed with organic acids (malic acid) but, although the proportion complexed with phenolics is

small, this can result in catalytic oxidation leading to deteriorative changes in fruit products.

Domestic Food Preservation.

Investigations of the safety of methods of preserving meat and poultry, begun in 1953, have been continued. The number of processes now examined is thought sufficiently large to warrant the publication of a bulletin, for which the script and photographs have been submitted to the Ministry of Agriculture, Fisheries and Food.

The methods for bottling and canning are based as closely as possible on those recommended by the U.S. Department of Agriculture in the bulletin "Home Canning of Meat," but modifications have been needed because of differences between American domestic equipment and that available in Britain. The work has so far entailed the preparation of over 350 heat penetration charts in which the temperature of food at the "cold spot" in the container and cooker has been determined throughout each process for comparison with the heat required to kill the spores of the heat-resistant bacterium P.A. 3679. Variations in the shape and thickness of glass jars, in the control of cooker temperatures, and in the evenness of domestic packs, allowed little reliance to be placed on nomograms prepared for the calculation of processing times in industrial canning.

The proposed bulletin contains a section on methods for deep-freezing meat, based on results obtained with chicken, pork and some pork products. Further work to compare the quality of frozen and cured pork products is in progress.

The examination of the adequacy of the methods recommended in Ministry publications for the bottling and canning of vegetables has been resumed; it had been suspended in order to give priority to the work with meat. During the year the heat-resistance of test organisms was studied in 13 kinds of vegetable purée.

The qualities of 11 raspberry and 16 strawberry varieties grown at the N.A.A.S. Sub-centre, Starcross, have been compared as fresh fruit and after preserving by bottling, by deep freezing, and by conversion to jam. Consistent results have been obtained in these trials, in which most of the raspberry varieties have now been tested for three years and the strawberries for at least two years.

The results of bottling and deep-freezing tests with 10 varieties of pear and 4 varieties of gage plum grown at Long Ashton are given in this Report (p. 170); ascorbic acid was added to the syrup of the frozen fruits in an endeavour to prevent oxidation during thawing. Fresh fruit flavour was judged in 49 varieties of gooseberry under investigation by the Pomology Section; 24 of these varieties have been bottled for tests of their preserving qualities.

Tasting trials for the detection of taints caused by spray treatments have included further tests of fresh, canned and frozen strawberries sprayed against *Botrytis*, and similar trials with gooseberries sprayed against mildew (see Pathology, p. 33). At the request of the Entomology Section storage trials are being carried out with black currants sprayed with Lindane at normal and high concentrations in a number of successive years in order to find whether Lindane has a cumulative effect on fruit quality. In these tests for taint the tasting panel has so far tasted over 380 individual samples in addition to 330 "triangles" (two treatments and one control, or vice versa) devised by the Statistics Section for estimating the significance of the results.

The suitability of 26 varieties of beans, and of 21 varieties of other vegetables, for canning and deep-freezing has been examined ; the amount of waste during preparation has been noted. The results for those vegetables tested for three years are given in this Report (p. 167).

Willows.

Variety Collection.

Of the 61 varieties received from Scotland in 1954 (1955 Report) 48 have been found identical with, or near hybrids to, those already in the Long Ashton variety collection. Five sub-alpine willows have been received from North Scotland, and two varieties of *Salix viminalis* from N. Ireland, bringing the total number of varieties in the collection to 179.

Experimental Work.

Measurements were made for the third year on a plot planted at Long Ashton in 1954 to study the root pattern of basket willows in relation to the chances of injury by mechanical cultivation. The likelihood of injury in this plot again appeared small : only 14·5% of the roots occurred in the surface 3 inches ; 40·0% occurred at a depth of 3–6 inches. It is proposed to repeat this experiment on the different kinds of soils used for basket willow cultivation.

In collaboration with the Entomology and Pomology Sections preliminary observations were made on the toxicity of 2:4-D, 2:4-DB, MCPA, MCPB, 2:4:5-T and 2:4:5-TB, when applied at a concentration of 0·1% to three species of basket willow. The bushes were sprayed to complete coverage of the upper surface of the foliage in August when the stool shoots were 4–5 feet long. *S. viminalis* var. Farnourianka was more susceptible to injury than either *S. alba* var. Vitellina or *S. triandra* var. Black Maul. 2:4-D, MCPA and 2:4:5-T produced a reaction after one day, 2:4-DB and MCPB after two days and, except in the 2:4:5-TB treatments, all aerial growth was killed within six weeks. Further experiments will be undertaken with 2:4:5-TB to investigate its use as a selective weedkiller in willow beds.

Five Cricket Bat willows were sold by the Station and information was obtained on the costs of utilization and on the relationship between the external appearance of the trees and the quality of their timber ; the quality of the Station timber was compared with that from two other sites. An experiment has been started to find what effect the period of check sustained by bat sets when planted in the field has on timber quality.

Advisory Work.

There were 219 requests for information during the year. 63 visits to growers were made as below :—

	South West.	*Home Counties.*	*East Anglia.*	*Midlands.*	*North.*	*Foreign.*
Number of enquiries	68	59	30	19	11	32
Number of visits	39	7	10	2	3	—

Two-thirds of the enquiries were concerned with basket willows and one-third with bat willows.

Requests for planting material included four from research and two from educational centres. There are now twelve sites at which willows are grown experimentally ; from these, data will be available on the growth of a large number of varieties in widely different climatic conditions. Advice has been sought by the Government of N. Ireland on the possibility of reviving the basket willow industry centred on Lough Neagh. Eleven varieties of basket willow from the Long Ashton collection were supplied for field trials.

S. triandra var. Black Maul was supplied to the Rural Industries Bureau (London) for investigations into the use of steam heating and chemicals in the peeling process. These experiments do not suggest that there is a satisfactory alternative to the present method of boiling.

The shortage of basket willows has continued. 1956 has been a poor growing season and no improvement in supplies is anticipated. A reliable estimate of national production is required, and since this information cannot be obtained from the Ministry of Agriculture returns, surveys of the Lancashire and Somerset willow-growing areas have been completed. Only 12 acres are devoted to basket willows in the once extensively planted Mawdesley district of Lancashire : mid-Somerset is now the only important area in Britain, with 1,327 acres, of which about 5% is unproductive. In mid-Somerset 17 acres were planted in 1956, despite the shortage of labour.

The investigation into the use of willows for paper pulp production has been continued in collaboration with the Forestry Commission and a firm of paper manufacturers. Considerable quantities of the crack willow (*Salix fragilis*) grow readily on the Somerset Levels. While the larger poles from pollarded trees have been found suitable for pulp-making, the large amount of material that has to be discarded makes a short-term (6-year) rotation uneconomic.

Statistics.

Experimental Design and Analysis.

Plot layouts have been prepared for long-term cider varietal trials at Long Ashton and in Herefordshire, and a number of short-term field projects were designed for the 1956 season. The design and analysis of field and laboratory trials for members of Station staff and for the University Horticultural Science Laboratories, and assistance in the presentation of the results, have again formed the primary task of the Section.

Earlier work on the sources of variation in incubator fungicide trials has been summarized (8) ; further experience has now been gained on this topic, and factorial types of design envisaged in the original paper on this subject have been planned and analysed. In collaboration with the Entomology Section, work has been started upon the mathematical representation of the shapes of droplets moving on an inclined plane (see Entomology, p. 30).

Collaboration has continued with the Domestic Food Preservation Section in the organisation of tasting panels for comparing samples of fruit subjected to different spray treatments ; alternative methods of allocation of samples to tasters and of recording tasters' reactions have been examined.

Biometric Studies.

Work on the relations between the 1956 crop weights and leaf analyses of black currants, using also shoot measurements obtained previously, is in progress. The examination of suitable measures of initial uniformity in branches of established trees for use in hormone spray trials is also being undertaken.

Studies of greenhouse environmental conditions will be resumed on the completion of the new range of houses.

Statistical sampling and recording methods have again been applied in many of the Station experiments, notably in collaboration with the Plant Pathology Section in the fungicide trials on Cox's Orange Pippin (p. 103).

AGRICULTURAL RESEARCH COUNCIL UNIT OF PLANT NUTRITION (MICRO-NUTRIENTS).

Plant Physiology.

Molybdenum nutrition in higher plants.

The investigation of factors affecting nitrate reductase activity in cauliflower was continued. It was confirmed that activity is greatly diminished by the exclusion of light ; on restoring light a renewal of activity is apparent in 1–2 hours, and normal activity returns in 12–24 hours. There is a similar recovery of lost activity when air is admitted to plants that have been kept in an atmosphere of nitrogen.

In studies of the effect of changes in nitrogen and molybdenum supply it was found that nitrate reductase activity in molybdenum-deficient cauliflower plants, grown with nitrate, increases within two hours on the addition of molybdenum to the culture medium. Portions of detached leaves made similar response when infiltrated with molybdenum but there was no response by disrupted cell preparations. The changes were initially similar on both a total and a specific activity basis and suggest that net total protein synthesis lags for six hours or more behind the increase in activity of enzyme protein. Similar responses were obtained when nitrate and molybdenum were introduced together into molybdenum-deficient plants, or portions of detached leaves, grown with ammonium sulphate : in the absence of either molybdenum or nitrate the response was small. These studies, which offer scope for the investigation of adaptive changes of enzyme activity in higher plants, are being continued.

Following improvements in technique, experiments suspended in 1954 have been resumed to study the combined effects of molybdenum supply and various nitrogen sources on the growth of tomato. Using in the first place nitrate and ammonium sulphate as nitrogen sources data have been obtained for growth rates, net assimilation rates, leaf growth and epidermal cell size, initiation of leaf primordia, protein synthesis, and the chlorophyll, ascorbic acid and molybdenum contents of plants grown in water cultures.

The changes associated with the development of Whiptail symptoms in cauliflower are being followed by a microscopical examination of the structure and composition of cell wall material, including histochemical tests for cellulose, pectin and hemicellulose.

Because of evidence that molybdenum deficiency influences phosphorus metabolism in cauliflower (Report for 1953), the fractionation of phosphate esters and other compounds in plants receiving different levels of molybdenum and different sources of nitrogen is being attempted, using radioactive phosphorus in conjunction with chromatographic and enzymatic procedures.

Aldehyde oxidase in potato. Further work on aldehyde oxidase (see Report for 1955) has shown that this enzyme, which is irreversibly inhibited by 10^{-4} M cyanide, is inhibited by sulphydryl inactivating agents ; subsequent dialysis

and incubation with a number of metal ions have not led to reactivation. At some stages of preparation it appears to be stimulated by molybdate and by flavin nucleotides under conditions that are being further investigated.

Essentiality of elements for higher plants. Work to test the essentiality of cobalt, vanadium, chlorine, etc. had to be abandoned during recent building operations ; it will be resumed on the installation of the new greenhouse equipment and the special reagent purification and controlled environment rooms.

Tissue Cultures. The new tissue culture laboratory has been equipped ; promising clones of tomato roots have been isolated and the effects of nutrient composition and purification are under investigation.

Analytical.

The spectrophotometric method developed for the estimation of ascorbic acid (Report for 1955) has been successfully applied to determinations in plants, weighing 200 mg. or less, during the growth experiment with tomato.

A method for the determination of nitrate in plant tissues containing 2–20 μg. nitrate nitrogen has been developed whereby ammonia produced by reduction with Devarda's alloy is distilled in a micro-Markham apparatus. The method has been found much more reliable than existing phenol-disulphonic acid methods for tissues containing low concentrations of nitrate.

Difficulty in obtaining valid blank values for nitrite in the estimation of nitrate and nitrite reductase has been shown to arise from interference by reduced diphosphopyridine nucleotide (DPNH) during the coupling reaction after diazotisation of the sulphanilamide reagent. The degree of interference is proportionately greater at low concentrations of DPNH : thus while the decrease in colour intensity is 24 per cent. with 50 mμM, the decrease is only 66 per cent. with 500 mμM. When the concentration of DPNH is constant the decrease is almost independent of nitrite concentration for values up to 100 mμM ; comparative differences are therefore little affected, and absolute values may be calculated when required. Interference is greater with nitrite solutions at pH 7·8 than with solutions at pH 4·0. No evidence for a reaction between nitrite and DPNH at physiological pH values has been found ; alcohol dehydrogenase produces normal changes in optical density in the presence of nitrite ; no deamination of the adenine component occurs and no compound formation has been noted. Nicotinamide, DPN and TPN do not interfere in nitrite estimations.

Culture Methods.

In further investigation of methods for growing cauliflower in water culture and for using ammonium sulphate to supply nitrogen to plants in water culture, it was found that the inclusion of 6 g. calcium carbonate per litre of culture solution led to healthy root development and greatly improved growth of cauliflower and tomato in the presence of ammonium sulphate ; the carbonate was kept in suspension by frequent stirring.

Satisfactory growth of cauliflower with nitrate in water cultures, as compared with growth in sand cultures, was obtained during late summer and autumn with plants grown by arranging the cultures so that roots were only partly immersed in solution ; the effects of root temperature are being studied and a routine method equally suitable for nitrate and ammonium nitrogen supplies is being sought. In several hundred plants grown at normal and

deficiency levels of molybdenum by the above method results with ammonium sulphate were usually as good as with nitrate, but severe root damage was caused by nitrite, particularly in molybdenum-deficient plants.

Nutrition of Micro-organisms.

Role of trace metals in enzyme systems of micro-organisms.

Nitrate Reductase. This enzyme, prepared from *Neurospora crassa*, has been shown to require phosphate for maximal activity (39). The phosphate requirement can be replaced completely by selenate, tellurate or arsenate and partially by sulphate or silicate ; adenosine triphosphate cannot substitute for inorganic phosphate. The enzyme is not inhibited by uncoupling reagents (dinitrophenol, aureomycin, sodium arsenite) and it is therefore likely that one of the functions of phosphate is to bind molybdate to the apoenzyme, since the replacement anions, which have similar atomic radii to phosphate (2·76 Å), also form complexes with molybdates.

In a study of the non-enzymatic reduction of nitrate by trivalent molybdenum it was found that pentavalent molybdenum (absorption spectrum 420 mμ) appeared simultaneously with the disappearance of trivalent molybdenum (absorption spectrum 500 mμ). The oxidation of trivalent molybdenum would therefore seem to proceed without the formation of an intermediate ; the direct transfer of two electrons to nitrate suggests a rupture of the nitrogen-oxygen bond.

Nitrite Reductase. Because of interference by reduced pyridine nucleotides in the standard method for the estimation of nitrite, a new procedure has been developed in which the nucleotides are adsorbed by barium acetate in ethanol before the addition of the nitrite test reagents. The enzyme is a flavoprotein, and preliminary results indicate that iron and copper may be required for maximal activity. The product of nitrite reduction is probably hyponitrite. The enzyme is inhibited by uncoupling reagents, e.g. dinitrophenol, so that a phosphorylation occurs at this step. The enzyme contains –SH groups.

Hyponitrite Reductase. This enzyme has been identified in *N. crassa*. It requires reduced diphosphopyridine nucleotides as the electron donor and forms hydroxylamine. It contains flavin and is inhibited by metal chelating agents including quinoline and cyanide, by uncoupling reagents, and by –SH inhibitors. It is thus a metallo flavoprotein and, like nitrite reductase, it appears to be linked to an energy-rich phosphate-conserving system ; its activity is low in felts deficient in iron or copper.

Hydroxylamine Reductase. This enzyme has been prepared from *N. crassa*. It is flavin dependent and produces ammonia from hydroxylamine in the presence of reduced diphosphopyridine nucleotide. It was found that extracts from manganese-deficient felts of *Neurospora* failed to catalyze this reaction whereas those from felts deficient in other trace metals showed maximal activity. The enzyme contains –SH groups and is unaffected by uncoupling reagents.

Catalase and Peroxidase. These two iron enzymes are much reduced in felts of *N. crassa* that are deficient in molybdenum. The addition of molybdenum to deficient felts *in vivo* restores to normal levels the weight of felts, and the activity of the two enzymes, within an incubation period of 24 hours. Infiltration of hydrogen peroxide *in vivo* also reconstitutes the two enzymes in the deficient felts but has no effect on their weight. Since molybdenum deficiency is known

to deplete some of the flavoproteins that produce hydrogen peroxide in the fungus, catalase and peroxidase, which utilize hydrogen peroxide, are thus reduced in activity. The addition of molybdenum *in vitro* to extracts of deficient felts activated neither enzyme, nor was an increase in the specific activity of the two enzymes during purification paralleled by an increase in their molybdenum contents, as determined by the ^{99}Mo technique. Molybdenum is therefore unlikely to be a constituent of the two enzymes (36).

Riboflavin mutant. Further work with a mutant of *N. crassa* that has an absolute requirement for riboflavin when grown at 30°C. but a less stringent requirement at 25°C. (see Report for 1955) has shown that its requirement of iron, copper, zinc, manganese and molybdenum at both temperatures is of the same order as that of the wild type ; it therefore seems unlikely that any of these metals is involved in the biosynthesis of riboflavin. When grown at 30°C. with optimal amounts of riboflavin its molybdenum requirement is increased because of an increased production of flavoprotein enzymes : when the riboflavin supply is limited there is increased activity of iron enzymes and a consequently greater requirement for iron. An account has been given of the electron transfer systems likely to be involved in these changes (37).

Hexokinase. A hexokinase which phosphorylates glucose and, at a lower rate, mannose, fructose and glucosamine, has been purified 60-fold from *N. crassa*. The phosphorylation product from glucose was shown by chromatographic and enzymic methods to be glucose-6-phosphate. The enzyme was competitively inhibited by N-acetyl glucosamine ; it was also inhibited by Na-EDTA, iodoacetate and *p*-chloromercuribenzoate, the inhibition of the last compound being reversed by glutathione. Zinc deficiency in the mycelial felts reduced hexokinase activity ; this initial low activity was brought up to 90% of the control levels within 12 hours of the addition *in vivo* of ionic zinc but not of Zn-EDTA. The increase in enzyme activity during purification was not paralleled by an increase in zinc content. This may be due to the ready removal of zinc from the enzyme during the fractionation procedure, for it was found that the partially purified enzyme was stimulated by adding ionic zinc. Zinc sulphate gave some protection to the –SH groups in the enzyme from inhibition by *p*-chloromercuribenzoate but the metal did not reverse the inhibitory effect when added after the inhibition ; the protective action of zinc could not be replaced by other metals.

Azotobacter and Clostridium. Although in both *Azotobacter vinelandii* (0 strain) and *Clostridium pasteurianum* iron deficiency is more readily produced than molybdenum deficiency, a deficiency of either micronutrient reduces the fixation of atmospheric nitrogen. In whole cells and in cell-free extracts of the two organisms iron deficiency was found to cause a marked reduction in hydrogenase activity : molybdenum deficiency had no effect on this enzyme. While iron would appear to be a constituent of the hydrogenase, it has not been possible to reactivate preparations of the enzyme from iron-deficient bacteria by the addition of ferric or ferrous ions, ferro-versenate, cytochrome c or boiled extracts of normal cells. In *Azotobacter* the enzyme is associated with cell particles, as only 5 per cent. of the total activity was found in cell-free extracts, whereas in *Clostridium* about 60 per cent. of the total enzyme was in the cell-free preparation. In *Azotobacter* the distribution of ^{59}Fe in the cell particles, separated by differential centrifugation, followed closely that of hydrogenase activity. Both ^{59}Fe and ^{99}Mo were removed slowly from homogenates of

Azotobacter dialysed against a variety of chelating agents, indicating that they were tightly bound to the cell proteins.

In measurements of nitrogen fixation and hydrogenase activity following the addition of various valence states of molybdenum and vanadium to culture solutions of *Azotobacter* freed from molybdenum, all valencies of both elements were equally effective in producing an increase in hydrogenase activity. The greatest increases in nitrogen fixation were, however, produced by hexavalent and pentavalent molybdenum ; the increase due to trivalent molybdenum was less, but greater than that produced by any of the vanadium valencies. Hydrogenase activity is therefore not always coupled with efficient nitrogen fixation.

Effect of Fungicides on Fungus Enzymes.

The effects of lime sulphur, copper sulphate, captan and *o*-hydroxydiphenyl on the enzyme patterns in *Sclerotinia laxa* and *Botrytis cinerea* were studied in collaboration with the Pathology and Chemistry Sections. Striking differences in the iron, flavoprotein and dehydrogenase enzymes could be correlated with the fungicide treatments (11).

Inorganic Chemistry.

Work on the separation of metallic valency states by paper chromatography was extended to include iron, manganese and copper.

Iron. A quantitative separation of ferrous and ferric iron was obtained upon paper chromatograms using solutions of the sulphates buffered to pH 3 4 with sodium acetate. Iron fractions were estimated as ferric thiocyanate after extraction into amyl alcohol-ether. The investigation led to the preparation of an 8-hydroxyquinoline complex of ferrous iron of the composition $Fe\ (C_9H_6ON)_2\ 2H_2O$ (50).

Manganese. Separations upon paper strips were achieved between di- and trivalent manganese as acetates, and between trivalent manganese and permanganate. The latter was slowly reduced to the lower valency states of manganese during the run on the chromatogram.

Copper. A good separation of cuprous and cupric copper was obtained using hydrochloric acid solutions of the chlorides. The run was carried out in an inert atmosphere to prevent oxidation of the cuprous state. By treating cuprous chloride with 8-hydroxyquinoline in pyridine medium, an oxine complex of cuprous copper was obtained which approached the composition $(Cu\ C_9H_6ON.\ C_9H_7ON)_2 \cdot C_5H_5N$.

Organic Chemistry.

The new phenolic substance reported in 1955 to occur in certain apple species has been shown to be a glucoside of 3′-hydroxyphloretin ; the position of the sugar residue in the glucoside has not yet been finally established. The substance is noteworthy as being the first naturally occurring dihydrochalkone with a hydroxylation pattern other than that of phloridzin (64). Its botanical distribution is of interest ; of the twenty-five species of *Malus* listed by Rehder only four, comprising the series Sieboldianae (Rehd.), contain it. It occurs in all hybrids of these species that have been examined, and otherwise has been found only in two varieties of other species. All the species concerned are of East Asiatic origin, mostly Japanese. The differences between species in this respect appear most clearly in the leaf, but also in the petal and bark. When

species containing this glucoside are grown on ordinary apple stocks, none of the substance can be detected below the union ; and conversely when an ordinary apple scion is grafted on to a seedling containing it, none can be detected above the union. There is no evidence that it is translocated in the plant.

A separation of *p*-coumaryl quinic acid in quantity sufficient for micro-chemical examination is being attempted, now that a Craig counter-current extraction apparatus is available, to supplement the tentative identification made on chromatographic evidence.

A chromatographic examination of the flavonols of apple and pear leaves indicates that in both a number of sugars are attached to the two aglycones quercetin and kaempferol, in contrast to the apparently exclusive occurrence of glucose derivatives of phloretin and hydroquinone in the leaves of apples and pears, respectively.

Study of the leuco-anthocyanins of pear bark is continuing in an attempt to obtain pure substances and derivatives.

In the carbohydrate fractions from tomato leaf, fructose, glucose, galactose, sucrose and inositol have been observed. There is a large increase in the carbohydrate content of leaves deficient in calcium or magnesium ; it appears to be a general increase in all the substances rather than an accumulation of particular individuals involving a change in their relative proportions. This contrasts with the behaviour of the carboxylic acids (malic and citric) which show changes in both absolute and relative amounts with variation in the levels of the major nutrients.

A REVISED LIST OF RECOMMENDED VARIETIES OF CIDER APPLES.

In 1948 a list of cider apple varieties recommended for planting was published in *Agriculture* (1) and in the Annual Report of the Research Station (2). This list, compiled by the Cider Advisory Committee of the Research Station, represented the views of various bodies interested in cider-making and cider-orcharding regarding suitable varieties to grow to meet post-war needs, and was based on the best information then available.

During the past nine years further information on the orchard performance of these recommended varieties has been collected, chiefly from the trial orchards planted by the Research Station in the cider-apple growing areas, and it is now apparent that some changes in the list are desirable. Some varieties, whilst of good vintage quality, have not performed well enough in the trial orchards to warrant continued recommendation for general planting, whilst others, about which little information was available in 1948, are now considered to show sufficient promise for inclusion in the list.

The revised list, given in Table I, is divided into two main groups A and B, and Group A is further sub-divided into two categories :—

Group A : Recommended varieties. This group comprises two categories :—

Category 1. Varieties of proved merit recommended for general planting in most cider-apple growing areas. They have been widely grown and are of good performance under average farm orchard conditions. These varieties should form a basis for any new orchard.

Category 2. Varieties that show promise in certain areas (given in brackets) but which cannot be recommended for general planting without further trial.

Group B : Varieties for special purposes. These varieties have some disadvantages but also certain outstanding qualities (given in brackets) which commend them for special purposes.

The varieties Sweet Alford, Tardive Forestier, Improved Foxwhelp and Backwell Red have been omitted from the revised list chiefly on account of their poor cropping records in certain localities. Many will regret the relegation of Kingston Black to the list of varieties for special purposes, but the poor cropping and susceptibility to disease of this variety have made this necessary. Another vintage quality apple, Stoke Red, has suffered a similar fate ; although it crops well the small fruit size of this variety is a strong disadvantage under present day conditions owing to the extra labour cost entailed in harvesting operations. It is still a useful apple to plant under certain conditions, particularly in frosty sites, where its late flowering is advantageous, and it has consequently been included in the list of varieties for special purposes. The only addition to the list of varieties recommended for general planting is Chisel Jersey, a variety which is known to do well in many of the cider-apple growing counties. No true sharp varieties occur in Group A of the new list, though a number of bittersharp varieties are included. The absence of sharps is due to the lack of demand for this type of apple in some cider-making districts.

In the 1947 list the recommended varieties were arranged according to juice classification (sweet, bittersweet etc.) and cider-making season. In the present list the arrangement has been altered, the varieties being grouped according to time of fruit fall in the orchard, a change which reflects recent developments in orchard planning and management. Whereas in the past, varieties of quite different season were planted together, in the best modern cider orchards the varieties are grouped according to time of fruit fall so that whole sections of the orchard may be harvested at the same time. This helps with labour and also, as most cider orchards are grazed, provides a longer season of usefulness for the cattle who share the orchard with the cider apple trees.

Another factor of importance in planning a cider orchard is the provision of suitable pollinators. This question did not arise in the older type of farm orchard containing a large mixture of interplanted varieties, but has arisen as a result of the modern tendency to plant relatively few varieties in blocks, many of which will set only poor crops with their own pollen. Moreover, not all varieties are equally good as pollinators for other varieties, and some, such as Bulmer's Norman and Court Royal, are quite useless. For this reason, advice on the choice of suitable pollinator varieties has been included in Table II,

which also summarizes the available information on the blossoming season, size and habit and orchard behaviour of all the varieties listed in Table I. The varieties of proved merit given in Table I do not provide a wide choice of harvesting season and it is desirable to find the varieties to fill the gaps. The list is thus not to be considered as a final one. Many of the varieties that show promise in certain areas have yet to be tried elsewhere and, as more information on these and other varieties becomes available, the list recommended for general planting will be lengthened.

The new list has been prepared by the Cider Advisory Committee of the Long Ashton Research Station, consisting of representatives of the Research Station, the National Farmers' Union, the National Association of Cider Makers, the Bath and West and Southern Counties Society, the National Agricultural Advisory Service and the County Councils of Devon, Dorset, Gloucestershire, Herefordshire, Monmouthshire, Somerset and Worcestershire.

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TABLE I.

RECOMMENDED VARIETIES.

Group A Time of Fall	**Category 1** (recommended for general planting)		**Category 2** (varieties that show promise)		
1st Season (*Before* 10th *Oct.*)			Breakwell's Seedling	Bittersharp	(Mon. & Heref.)
			Néhou	Bittersweet	(Heref.)
			Reine des Hâtives	Sweet	(Heref.)
			White Norman	Bittersweet	(Heref.)
2nd Season (10th *to the end of Oct.*)	**Bulmer's Norman**	Bittersweet			
3rd Season (1*st-*20*th Nov.*)	**Court Royal**	Sweet	Brown Snout	Bittersweet	(Heref.)
	Sweet Coppin	Sweet	Lavignée	Bittersweet	(Heref.)
	Tremlett's Bitter	Bittersweet	Michelin	Bittersweet	(Heref.)
	Yarlington Mill	Bittersweet	Northwood	Sweet	(Devon)
			Porter's Perfection	Bittersharp	(Som.)
4th Season (20*th Nov. onwards*)	**Ashton Brown Jersey**	Bittersweet	Fillbarrel	Bittersharp	(Som.)
	Chisel Jersey	Bittersweet	Harry Master's Jersey	Bittersweet	(Som.)
	Dabinett	Bittersweet	Sandford Jersey	Bittersweet	(Som.)
			Vilberie	Bittersweet	(Heref.)

Group B			
2nd Season	Brown's Apple	Sharp	(sharp)
3rd Season	Kingston Black	Bittersharp	(vintage quality)
4th Season	Crimson King	Sharp	(good orchard behaviour—sharp)
	Médaille d'Or I (Spreading)	Bittersweet	(very late flowering)
	Stoke Red	Bittersharp	(late flowering and vintage quality)

TABLE II.

ORCHARD CHARACTERS OF RECOMMENDED VARIETIES.

Variety	Season of blossoming	Suitable pollinators*	Self fertility	Size and habit of tree	Notes on orchard behaviour
1. Ashton Brown Jersey	4th	3, 6, 9, 10, 11, 12, 15, 17, 22, 25, 21, 2, 16, 18, 19, 26		Medium, semi-spreading	
2. Breakwell's Seedling	3rd	16, 18, 19, 26, 1, 3, 6, 9, 10, 11, 12, 15, 17, 22, 25, 26		Medium, semi-spreading	Fruit should be harvested promptly.
3. Brown's Apple	4th	1, 6, 9, 10, 11, 12, 15, 17, 22, 25, 21, 2, 16, 18, 19, 26		Medium, upright	
4. Brown Snout	6th	14, 24, 21		Medium	Trees liable to split at crotch.
5. Bulmer's Norman	2nd	2, 16, 18, 19, 26, 13, 23	Poor	Large, spreading	Generally healthy; usually biennial; liable to split at crotch.
6. Chisel Jersey	4th	1, 3, 9, 10, 11, 12, 15, 17, 22, 25, 21, 2, 16, 18, 19, 26	Fair	Medium, spreading	Fruit size variable.
7. Court Royal	2nd	2, 16, 18, 19, 26, 13, 23	Poor	Large, spreading	Generally healthy, but sometimes susceptible to scab and brown rot.
8. Crimson King	2nd	2, 16, 18, 19, 26, 13, 23	Poor	Large, semi-spreading	
9. Dabinett	4th	1, 3, 6, 10, 11, 12, 15, 17, 22, 25, 21, 2, 16, 18, 19, 26	Good	Small, spreading	Needs good growing conditions.
10. Fillbarrel	4th	1, 3, 6, 9, 11, 12, 15, 17, 22, 25, 21, 2, 16, 18, 19, 26		Small, semi-spreading	Fruit often small.
11. Harry Master's Jersey	4th	1, 3, 6, 9, 10, 12, 15, 17, 22, 25, 21, 2, 16, 18, 19, 26		Medium, semi-spreading	
12. Kingston Black	4th	1, 3, 6, 9, 10, 11, 15, 17, 22, 25, 21, 2, 16, 18, 19, 26	Fair	Medium, semi-spreading	Subject to scab and canker; not a heavy cropper.
13. Lavignée	1st	23		Small, semi-spreading	
14. Médaille d'Or I (Spreading)	7th	4, 24	Good	Small, spreading	Precocious; later growth may be weak; not usually suitable for a standard tree; fruit often small.
15. Michelin	4th	1, 6, 9, 10, 11, 12, 17, 22, 25, 21, 2, 16, 18, 19, 26, 3	Good	Medium, upright	
16. Néhou	3rd	2, 18, 19, 26, 1, 3, 6, 9, 10, 11, 12, 15, 17, 22, 25, 26		Medium, semi-spreading	
17. Northwood	4th	1, 3, 6, 9, 10, 11, 12, 15, 22, 25, 21, 2, 16, 18, 19, 26		Large, semi-spreading	
18. Porter's Perfection	3rd	2, 16, 19, 26, 1, 3, 6, 9, 10, 11, 12, 15, 17, 22, 25, 26		Large, spreading	
19. Reine des Hâtives	3rd	2, 16, 18, 26, 1, 3, 6, 9, 10, 11, 12, 15, 17, 22, 25, 26		Medium, semi-spreading	Fruit often small.
20. Sandford Jersey				Medium, semi-spreading	Needs good growing conditions.
21. Stoke Red	5th	14, 24, 1, 3, 6, 9, 10, 11, 12, 15, 17, 22, 25	Fair	Medium, semi-spreading	Slow growing, but eventually reaches a fair size; fruit often small.
22. Sweet Coppin	4th	1, 3, 6, 9, 10, 11, 12, 15, 17, 25, 21, 2, 16, 18, 19, 26	Good	Large, semi-spreading	Usually healthy.
23. Tremlett's Bitter	1st	13	Poor	Medium, semi-spreading	
24. Vilberie	6th	4, 14, 21		Large, spreading	
25. White Norman	4th	1, 3, 6, 9, 10, 11, 12, 15, 17, 22, 21, 2, 16, 18, 19, 26		Small, spreading	Susceptible to scab; needs good growing conditions.
26. Yarlington Mill	3rd	2, 16, 18, 1, 3, 6, 9, 10, 11, 12, 15, 17, 19, 25	Fair	Medium, semi-spreading	

* Bulmer's Norman, Court Royal and Crimson King are useless as pollinators.

PERRY PEARS FOR PLANTING.

By R. R. WILLIAMS.

At the request of the Cider Advisory Committee of the Research Station, a list of perry pears, prepared from information obtained during a survey of varieties in the West Midlands (1,2,3), is presented for the guidance of those who may wish to plant perry pears in the near future. The list provides a selection of twenty varieties that have been under observation for four years. Unfortunately no reliable yield data are available, but crop records will presently be obtained from a number of trial orchards that are now being established, and at a later date it is hoped that the Advisory Committee will be able to publish a Recommended List of perry pears similar to that now published for cider-apples (4).

Orchard and Vintage Characters.

The main characters of the varieties are summarized in Table I.

Variety names. The nomenclature of perry pears is very confused : many of the names given in the list are used for varieties other than those described. A list of common synonyms has been published (1) and some of the more general ones are quoted in Table I. Should there be any doubt about the identity of any variety, reference should be made to the Research Station.

Harvesting times. The harvesting period given in the table is for an average season ; harvesting may be slightly earlier or later in some seasons. Both the condition and the keeping quality of the fruit depend upon harvesting at the correct time. It will be seen from the table that some varieties must be sent to the factory very soon after harvesting.

Cropping capacity. Many varieties are disappearing with the present wide-spread grubbing of old orchards ; for this reason observations have sometimes been confined to a very small number of trees. The recommendation of such varieties is largely based on their good reputation with growers.

Tree size. Many perry pear trees attain the dimensions of forest trees and need at least 72 ft. between each other. Planting at this distance would be uneconomic as the trees take a considerable time to reach mature size. It is recommended that trees be planted at half this distance, using alternate vigorous and weak-growing trees ; this will allow for eventual thinning to leave the desired varieties.

Susceptibility to scab and canker. The culture of the perry pear has been restricted to the West Midlands and, except for some trees distributed by the Research Station, has not extended south or west of Bristol. Orchard observations of trees propagated by Long Ashton suggest that in the higher rainfall areas of the south-west susceptibility to scab and canker would prevent the culture of many varieties. Varieties prone to these diseases should be planted only in districts known to be suitable.

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TAB

PERRY PEARS

Variety	Distribution	Harvesting time	Milling (time after harvesting)	Cropping capacity	Fruit size	Tree si
Arlingham Squash *Syn.* Squash Pear, Old Squash	Only a few trees remain	1st–3rd week October	5 days	Good	Large	Mediu
Barnet *Syn.* Barn Pear	Scattered, infrequent	1st–2nd week October	3 weeks	Good, usually better in alternate years	Large	Mediu
Blakeney Red	Scattered, common	4th week September-2nd week October	1 week	Good	Very large	Large
Brandy	Observations confined to a single tree	1st-4th week October	1-4 weeks	Good, biennial	Large	Small
Butt	Scattered, common	1st-2nd week November	4-10 weeks	Good	Large	Large
Chaceley Green	Observations confined to a single tree	2nd-4th week October	3 weeks	Very good	Medium	Small
Flakey Bark	Local variety; only a few trees exist	2nd-4th week October	3 weeks	Good, usually better in alternate years	Very large	Large
Gin	Common in a few parishes	2nd-3rd week October	3-5 weeks	Good	Medium	Mediu
Gregg's Pit	Common in a few parishes	4th week September-1st week October	2 weeks	Fairly good	Medium	Large
Hendre Huffcap	Local variety; only a few trees exist	1st-2nd week October	2 weeks	Good	Large	Large
Judge Amphlett	Scattered, infrequent	3rd week September-1st week October	1 week	Good	Large	Mediu
Moorcroft *Syn.* Malvern Hills	Scattered, common	3rd-4th week September	2 days	Fairly good	Very large	Large
Oldfield *Syn.* Olleville	Scattered, common	3rd-4th week October	3-6 weeks	Fairly good	Medium	Small
Red Longdon	Scattered, infrequent	1st-2nd week October	3 weeks	Fairly good	Very large	Mediu
Red Pear *Syn.* Aylton Red, Red Horse	Scattered, common	1st-3rd week October	3 weeks	Fairly good	Medium	Mediu
Rock *Syn.* Black Huffcap, Brown Huffcap	Scattered, common	4th week October-1st week November	8 weeks	Fairly good	Medium	Mediu
Thorn	Scattered, common	3rd-4th week September	1 week	Good	Very large	Small
Turners Barn *Syn.* Longstalk	Scattered, common	2nd-4th week October	3 weeks	Good	Medium	Small
Winnal's Longdon	Common in a few parishes	1st-2nd week October	1 week	Good	Very large	Mediu
Yellow Huffcap *Syn.* Chandos Huffcap	Scattered, common	1st-3rd week October	1 week	Good, may be strongly biennial	Medium	Large

Susceptibility to scab and canker	Type of perry	Notes
Moderate	Sweet	Popular during 18th century in Gloucestershire ; fruit sweet and often attacked by wasps before ripe ; rots quickly from centre, remaining sound in appearance.
Little or none	Sweet	Propagated by Long Ashton Research Station in early part of this century ; forms a compact tree which does not break down with heavy crops ; fruit shakes easily ; limited plantings in Somerset have been successful.
Little or none	Bittersharp	A dual purpose pear (culinary and perry) generally used for perry today ; most reliable cropper among the common varieties ; period of milling widely considered to decide quality of perry ; limited plantings in Somerset have been successful.
Little or none	Sweet	Popular during 19th century ; often planted when small trees required ; trees consequently easy to grub and variety has practically disappeared in last 10 years ; reputed to make a strong perry.
Little or none	Bittersharp	A very common variety and one of the most popular grown today ; originally planted for wine trade as a diluent for imported wines ; fruit may be left lying on the ground for months until required.
Little or none	Sweet	A little known variety once grown around Tewkesbury ; it has an exceptional orchard reputation and should be considered for planting today.
Slight	Bittersharp	A very promising local variety ; the main limbs lose their bark each year ; exceptionally high in tannin.
Little or none	Bittersharp	A promising local variety ; the keeping quality of the fruit is a valuable attribute often lacking in perry pears.
Moderate	Sharp	Very vigorous trees ; fruit may be small in some years.
Little or none	Sweet	Very upright trees ; branches sometimes break down through heavy crops ; fruit shakes easily.
Little or none	Bittersharp	Propagated by Long Ashton Research Station in early part of this century ; one of the heaviest cropping early varieties ; limited plantings in Somerset have been successful.
Moderate	Bittersharp	The limbs break easily through weight of crop or when shaking ; difficult to shake and needs harvesting over a period of at least a week ; sometimes scabs severely.
Severe	Bittersharp	Once of high repute as a vintage quality variety ; very susceptible to scab and canker ; not recommended unless known to do well in locality.
Moderate	Bittersharp	A variety rapidly disappearing ; considered by T. A. Knight in 1811 to be seeing the end of its useful life ; probable that trees have a shorter life than most perry varieties.
Moderate	Sweet	Popular for over 400 years ; trees still appear to do well in many localities.
Slight	Bittersharp	A more recent variety, believed to be only 150 years old ; fruits hang in clusters of 5-9 ; will not mature during storage but slowly turn black with dry rot. The high gravity and astringency of juice are well known.
Slight	Sweet	Once used for dessert purposes ; upright habit and small size of tree have made this heavy cropping variety popular with many growers.
Little or none	Sharp	Upright growing trees ; usually considered of high vintage quality.
Little or none	Bittersharp	Fruit should be harvested before it begins to drop in quantity.
Little or none	Bittersharp	A variety of high repute ; fruit must be shaken just before it is ripe or it may rot on the tree.

ROSETTING AND INCOMPATIBILITY OF PEARS ON QUINCE A: PROGRESS REPORT I.

By R. R. WILLIAMS and A. I. CAMPBELL.

Introduction.

Quince A has long been regarded as one of the best rootstocks for the production of bush pear trees, but since 1953 difficulty has been experienced at Long Ashton in the propagation of certain varieties of pears on this stock. Trouble was first encountered when perry pears were budded on Quince A to provide material for an orchard of bush perry trees that would come into cropping more quickly than trees worked in the traditional manner on seedling pear stocks. In the spring following budding it became obvious that the development of some varieties was unusual : a rosette of a few small leaves appeared and extension growth was completely inhibited or delayed until the summer. No symptoms of this kind had been noted previously in dessert pears or in perry pears, though it seems unlikely that there had been many previous attempts to work perry pears on Quince A. The more usual type of incompatibility, as seen in Williams' Bon Chrétien on Quince, was also found.

In 1956 similar symptoms of rosetting and incompatibility appeared in the Long Ashton nursery in the variety Conference worked on Quince A ; this variety had previously made consistently good growth on Quince A. The examination of a number of commercial nurseries in the South of England during the summer of 1956 showed that rosetting was present on other dessert pear varieties besides Conference.

The present paper gives an account of observations made at Long Ashton and in some commercial nurseries, and of preliminary investigations of the cause of incompatibility and rosetting.

Initial observations on perry pears.

Single-worked trees.

In 1953 fourteen varieties of perry pears were budded on Quince A stocks from the Long Ashton stoolbed. They appeared normal until bud burst in the following year when five of the varieties produced small rosettes of leaves (Fig. 1). After a period of three or four weeks, during which they made no extension growth, four of the five varieties grew out and by mid-summer appeared almost normal (Fig. 3) though one of the four, Butt Pear, died back from the tip at the end of the year. The fifth variety, Blakeney Red, made no extension growth ; the small rosette remained alive for three or four months and then gradually died.

In early September the colour of the leaves of each variety was noted and the height measured as an assessment of vigour. The varieties that made a rosette were in all instances much less vigorous.

Most varieties showed signs of virus infection such as ring spots, vein yellows and red mottle. It was not possible to identify the ring spot with any virus symptom previously described on pears, but the vein yellows and the red mottle were similar to those described by Posnette (1).

The strength of union at the end of the first year was found to be variable both between and within varieties, though no reliable index of strength could be obtained by application of a breaking test similar to that described by Chang (2) or by a water conductivity test described by Warne (3).

Tests of union strength were made by comparison with Laxton's Superb, Doyenne du Comice and Conference. While the first two were uniformly strong, Conference and many of the perry varieties seemed to have a proportion of weak unions. This is a finding of some consequence because Conference is the most widely planted pear in the country and, in addition, it is sometimes used as an intermediate for other varieties.

With all the varieties tested, budwood had been taken from a single parent tree : variation within a variety therefore seemed to indicate variation within the Quince A rootstocks used.

Double-worked trees.

The failure to raise perry pears by direct budding on Quince A suggested the use of Beurré Hardy as an intermediate. In 1954, 260 trees of Beurré Hardy were budded on Quince A, and in 1955 the perry scion varieties were budded on the Beurré Hardy two inches above the original union.

TABLE I.

BEHAVIOUR OF MAIDEN TREES OF PERRY AND DESSERT PEARS ON QUINCE A

Variety		Spring symptoms	Virus symptoms	Early autumn colour	Vigour
Blakeney Red	Single worked	Rosette of leaves	—	Trees died	No extension
	Double worked	„ „ „	M	Green	Very weak
Barland	Single worked	Rosette of leaves	—	Red	Medium
	Double worked	Normal extension	—	Red	Strong
Butt	Single worked	Rosette of leaves	—	Green	Weak
	Double worked	„ „ „	—	Green	Medium
Aylton Red	Single worked	Rosette of leaves	—	Yellow	Medium
	Double worked	„ „ „	M	Green	Medium
Judge Amphlett	Double worked	Rosette of leaves	—	Green	Weak
Moorcroft	Single worked	Normal extension	Y	Yellow	Strong
	Double worked	„ „	Y & M	Green	Strong
Bartestree Squash	Single worked	Normal extension	Y	Green	Strong
	Double worked	„ „	Y	Green	Strong
Yellow Huffcap	Single worked	Normal extension	Y	Green	Medium
	Double worked	„ „	Y	Green	Medium
Oldfield	Single worked	Normal extension	—	Yellow	Medium
	Double worked	„ „	—	Green	Strong
Rock	Single worked	Normal extension	—	Green	Strong
	Double worked	„ „	—	Green	Strong
Sack	Single worked	Normal extension	—	Red	Strong
Arlingham Squash	Single worked	Normal extension	—	Orange	Strong
Holmer	Single worked	Normal extension	—	Green	Medium
Pine	Single worked	Normal extension	—	Green	Very strong
Red Longdon	Double worked	Normal extension	Y & M	Green	Strong
Turner's Barn	Double worked	Normal extension	Y & M	Red	Strong
Gin	Double worked	Normal extension	Y	Green	Strong
Conference	Single worked	Normal extension	—	Green	Strong
Doyenne du Comice	Single worked	Normal extension	—	Green	Very strong
Laxton's Superb	Single worked	Normal extension	—	Green	Very strong

M = Red mottle on leaves of interstock ; Y = vein yellows on leaves.

While rosetting again appeared in four of the double-worked varieties, the trees were more vigorous than those worked directly on to Quince A. Blakeney Red, for instance, was about 6 inches high at the end of the first year whereas the single worked trees had entirely failed to grow. The double-worked trees showed less early autumn colour, and when examined at the end of the year the union strength was satisfactory (see Table I).

Experimental.

Variability of Quince A in Long Ashton Stoolbed.

The variation in the strength of the union between Quince A and varieties such as Conference, in which all the bud wood had been taken from the same tree, suggested that the Quince A in the Long Ashton stoolbed might either not be a true clone or be infected with virus. An examination of the stoolbed showed that the stools were morphologically true to type and varied only in the number and size of shoots produced. To investigate the possibility that a correlation might exist between vigour of a stool and incompatibility, the stools were divided into the following groups : A, strong and prolific ; B, strong and sparse ; C, weak and prolific ; D, weak and sparse.

In the winter of 1954-55, 50 grade I stocks were taken from the stools in each group ; these were lined out in five randomised blocks each containing 4 unit plots of ten trees, and were subsequently worked with Conference buds from a single mother tree.

During the winter of 1955-56, 49 stocks died. In the following spring, 39 of the 151 surviving trees were grafted : all made normal trees. The budded trees produced a high percentage of rosetted shoots, some of which made normal growth later in the season. Their condition when examined in July is shown in Table II and Fig. 2. There was no correlation between rootstock vigour and the rosette symptoms shown by Conference.

TABLE II.

CONFERENCE MAIDENS ON LONG ASHTON QUINCE A

	Rootstock group			
	A strong ; prolific	B strong ; sparse	C weak ; prolific	D weak ; sparse
Summer symptoms.				
Category 1*	5	1	2	5
„ 2	3	10	9	4
„ 3	10	12	14	14
„ 4	7	7	7	2
Union Strength.				
Number of trees	18	29	30	19
Number snapping cleanly at union	3	7	8	7
Weak unions (per cent.) ..	17	24	27	37

* Categories. (1) Buds not grown out ; (2) Buds grown out to form rosette of leaves and sometimes numerous short shoots with small leaves ; (3) Initial rosetting followed by extension growth which may show abnormal leaves, small, cupped or tattered ; (4) Normal.

During the following winter the strength of the unions was tested by holding the rootstock rigid immediately below the union and bending the scion outwards to an angle of 45°. Some unions snapped off easily giving a clean break

while others remained undamaged (Table II). The data suggested that the rootstocks from the weaker stools gave a higher proportion of weak unions than those from the vigorous stools, but owing to the small numbers of trees available for the test the differences failed to reach an acceptable level of statistical significance. There was no correlation between the various summer abnormalities and strength of union.

An examination of typical strong and weak unions in the laboratory showed considerable differences in their anatomy. In weak unions there was no continuity between the xylem of the quince and that of the pear, the graft components being separated by an almost continuous band of phloem and cortical tissue (Fig. 4). In addition there was no union between the cambia, which were separated by an area of dead cells : hence the xylem union had taken place through the wood parenchyma developed during the previous year between the bud and the stock. Although the union was apparently sufficient to allow development of the scion, there were signs that the parenchyma was already breaking apart.

The strong unions show normal development with the two xylem tissues united (Fig. 5).

Varietal behaviour on Quince A from two sources.

Symptoms of virus disease were common in the perry pear scions used in the initial attempt to grow them on Quince A. Before carrying out further propagation an attempt was therefore made to find parent trees free from virus symptoms, and in the summer of 1955 a survey was made of those varieties that had rosetted on quince. No trees free from virus disease could be found, the rosetting varieties appearing to be more frequently affected by ring-spot than other varieties.

Since Blakeney Red and the other perry varieties grow well when budded on seedling pear, rosetting appeared to be associated with the use of Quince A. To find whether this was a peculiarity of the Long Ashton rootstocks, comparative trials were made in the summer of 1955 with rootstocks obtained from a commercial nursery in which no difficulty in propagating dessert pears had been experienced. Conference was used in addition to a number of perry pear varieties that had shown a range of incompatibility symptoms. Four replicates of 24 buds of each variety were used, using split plots in which 12 were worked on Long Ashton Quince A and 12 on the Quince A from the commercial nursery.

In the summer of 1956 the appearance of the trees was similar to that of the trees in the original experiment (see Table III). In some varieties, Conference, Blakeney Red and Aylton Red, a high proportion of the buds, all of which had appeared alive in the early spring, subsequently died after having failed to grow out ; these varieties subsequently produced many rosetted trees. The others, Moorcroft, Rock and Barland, showed fewer bud deaths and less rosetting, but within this group there was no close correlation between bud death and rosetting. If the incidence of rosetting in the surviving trees is considered, it will be seen that Conference, Aylton Red and Moorcroft produced more rosetted plants on the Long Ashton Quince A than on the commercial stock ; these differences are highly significant ($P<0{\cdot}1\%$). All Blakeney Red trees were rosetted on stocks from both sources whereas Barland and Rock were affected only slightly.

TABLE III.

PERFORMANCE OF PEAR VARIETIES ON QUINCE A FROM TWO SOURCES.

Variety	Source of Quince A	Scion Growth					Total number of trees
		Bud dead	Rosetted		Weak extension growth	Normal	
			(no. trees)	(per cent. of trees surviving)			
Conference	Long Ashton	21	17	65	6	3	47
	Commercial	29	6	37	5	5	45
Blakeney Red	Long Ashton	19	29	100	0	0	48
	Commercial	27	20	100	0	0	47
Barland	Long Ashton	7	1	2	15	25	48
	Commercial	12	1	3	7	28	48
Aylton Red	Long Ashton	11	21	57	15	1	48
	Commercial	15	7	21	24	2	48
Rock	Long Ashton	9	1	3	4	34	48
	Commercial	5	0	0	2	38	45
Moorcroft	Long Ashton	4	6	14	10	28	48
	Commercial	5	1	2	4	38	48

Visits to Nurseries.

During 1956 ten commercial nurseries were examined in order to determine the prevalence of this disorder. In five nurseries, including the one from which the experimental Quince A stocks were obtained, the trees appeared normal. In three nurseries rosetting was particularly severe ; here it was stated that this condition had appeared only in recent years and that it was becoming progressively worse each year. A similar report was received from a Scottish nursery. In the two other nurseries the number of rosetted trees was small. A comparison of the varietal susceptibility to rosetting found in the affected nurseries is given in Table IV.

TABLE IV.

VARIETAL SUSCEPTIBILITY TO ROSETTING.

Highly resistant	Moderately susceptible	Highly susceptible
Beurré Hardy	Doyenné du Comice	Conference
Fertility	Laxton's Superb	Emile d'Heyst
Louise Bonne	Williams' Bon Chrétien	Glou Morceau
	Bristol Cross	Gorham
		Joséphine de Malines
		Pitmaston Duchess

There was considerable variation in the exposure of sites visited, but neither this nor the average monthly temperatures recorded during the winter

in the vicinity of the nurseries appeared to be correlated with the severity of rosetting.

Discussion.

The abnormalities that have been observed in the growth of pears on Quince A stocks appear to be of three distinct types : death of buds (all varieties, particularly Conference and Blakeney Red); brittle unions (Moorcroft, Barland, Conference) : and rosetting of maiden growth (Blakeney Red, Aylton Red, Conference, Emile d'Heyst, Pitmaston Duchess). There seems no reason to suppose at present that these three symptom types are all due to the same cause, though the possibility that this is so cannot be entirely ruled out.

It seems highly likely that the high death rate of buds in the 1955 trial was due to abnormal weather conditions during the spring of 1956, when very mild weather in January was followed by exceptionally low temperatures in February. At Long Ashton the minimum screen temperature for the last four days of January was 45°F, and for the first four days of February only 15°F. Such a sudden drop in temperature might well have caused damage to buds whose dormancy was already broken.

The brittle unions observed when the varieties Moorcroft, Barland and Conference were worked on Quince A are of the Williams'-quince type of incompatibility which is normally overcome by double working. That this incompatibility occurred in some but not others of the Conference pears budded on Quince A suggested lack of uniformity in the Long Ashton rootstocks, since all the buds had come from one parent tree. Experiment showed that the weaker stools gave a greater number of brittle unions.

No previous reference to rosetting of pears on quinces has been seen. This trouble occurs even when the union is strong ; it is not overcome by double working, which does, however, reduce the severity of the symptoms. Less severe symptoms are also shown when susceptible varieties are grafted rather than budded.

Since stunted growth and rosetting are associated with virus infection in many plants, it is possible that a stock or a scion virus, or a combination of both is involved. It has been shown that rootstocks from two sources may give a different incidence of rosetting. It has also been noted that many of the scion varieties examined show a wide range of virus symptoms which, however, have not yet been shown to be associated with rosette or with any of the other disorders described. Further work on this subject is in progress.

Summary.

Increasing difficulty has been experienced in recent years in propagating dessert, culinary and perry pears on Quince A. Three types of abnormality have been observed : rosetting, brittle unions and bud death. Preliminary investigations to determine the cause of these disorders are described and the possibility that virus disease, incompatibility and winter injury are involved is discussed.

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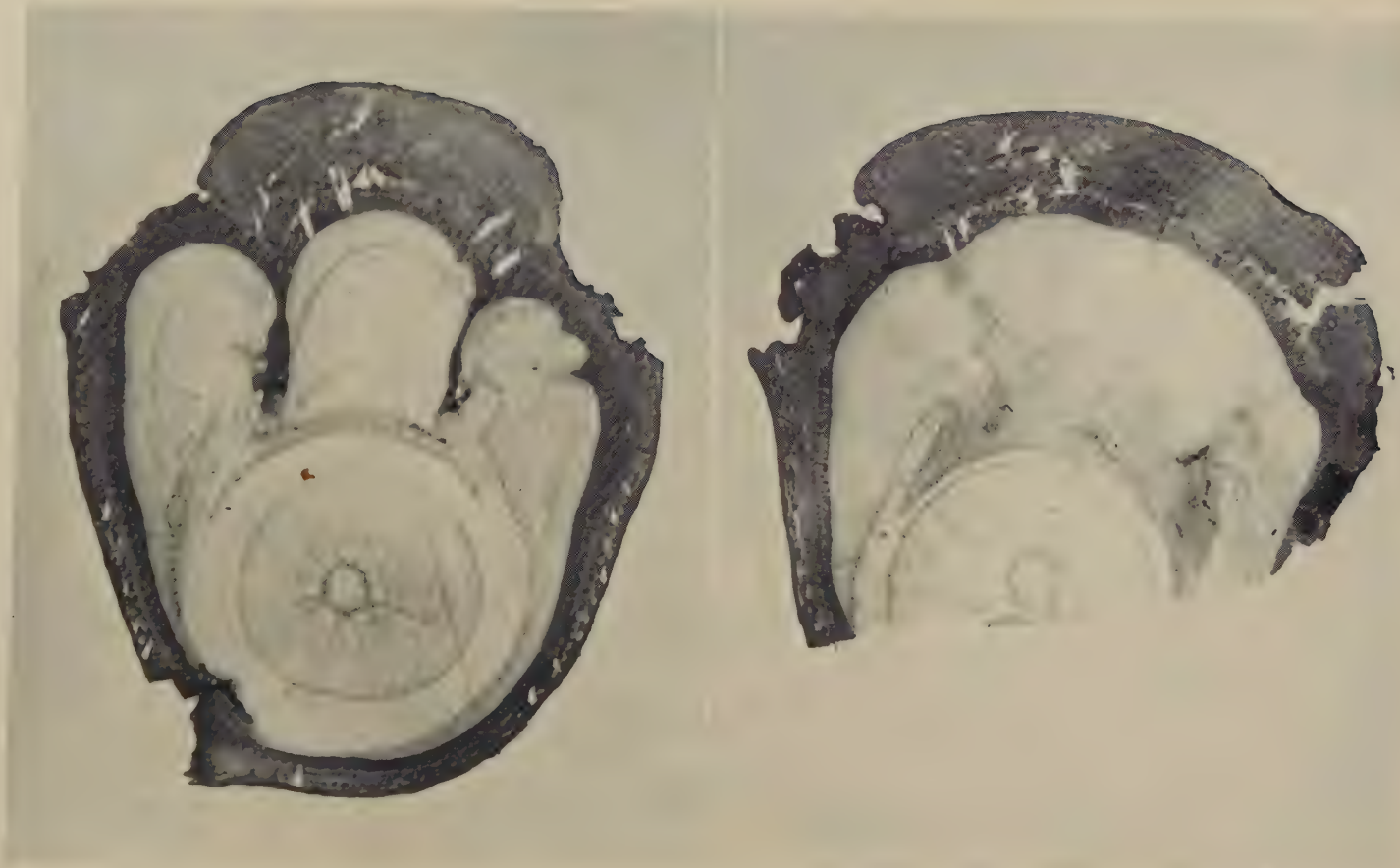
Fig. 1. Rosette in Blakeney Red budded on Quince A.

Fig. 2. Rosette in Conference budded on Long Ashton Quince A.

Fig. 3. Normal extension growth following rosette in Aylton Red budded on Quince A.



Unions produced by budding Conference on Long Ashton Quince A.

Fig. 4. Incompatible.

Fig. 5. Compatible.

GROWTH SUBSTANCES AS FRUIT-THINNING AGENTS FOR APPLES: PROGRESS REPORT.

By D. L. ABBOTT.

Introduction.

A previous report (1) described a small trial in which 1-naphthaleneacetamide (NAm) was sprayed on two varieties of apple as a fruit-thinning agent. Fruitlets of Crawley Beauty were very effectively thinned by the spray and at 25 p.p.m. the marketable crop was significantly increased. Treatment was, however, without any apparent effect on Laxton's Superb, even when applied at 75 p.p.m.

In 1956 Crawley Beauty and Laxton's Superb were again sprayed to confirm the results already obtained, and the trial was extended to cover another four varieties of diverse bearing habit to assess the range of varietal susceptibility. The results of this experiment are reported below, together with observations on the cropping in 1956 of trees sprayed in 1955.

Method.

As in the previous trial, NAm, formulated as a dry wettable powder, was applied as an aqueous suspension at concentrations of 25 and 50 p.p.m. to individual limbs of the six varieties. Control branches were not sprayed. Each treatment was applied to one branch of each of 8 mature bush trees of Miller's Seedling but, in order to obtain eight replicates on branches that were uniform in size and vigour and in the number of blossom clusters, it was necessary to randomize the treatments amongst 10 trees of Lord Lambourne and Crawley Beauty, 13 trees of Worcester Pearmain and 20 trees of Lane's Prince Albert. There were available only 5 trees of Laxton's Superb in a fully " on-year " condition, hence 3 trees carrying only light blossom were also used; these latter trees are referred to as " off-year " trees and have been treated separately in the analysis of results.

Branches of Lord Lambourne and Worcester Pearmain were sprayed 2 days after petal-fall, those of Miller's Seedling and Lane's Prince Albert 3 days after petal-fall, and those of Laxton's Superb and Crawley Beauty 4 days after petal-fall. The weather was fine and warm on each occasion except that on which Crawley Beauty was sprayed, when it was cool and cloudy with some sunny intervals.

Results.

There was again no epinastic drooping of the foliage on any variety following application of the spray, but some inhibition of leaf growth became apparent on Lane's Prince Albert within approximately two weeks. This was more severe on the branches sprayed at 50 p.p.m., but both concentrations caused a considerable yellowing of the foliage. There was, however, no reduction of foliage cover on Crawley Beauty such as had been observed in 1955. Abscission of small fruitlets that had ceased growing was again delayed by the sprays.

At harvest, fruit from each branch was weighed and graded by size. Table I summarizes these data; as in previous reports, fruits smaller than $2\frac{1}{4}''$ in diameter are classed as unmarketable and those larger than $2\frac{1}{4}''$ as marketable.

TABLE I.

SUMMARY OF HARVEST DATA.

Variety	Treatment	Mean wt. fruit/100 blossom clusters (Kg)	Mean No. fruit/100 blossom clusters	
			Unmarketable ($<2\frac{1}{4}''$)	Marketable ($>2\frac{1}{4}''$)
Miller's Seedling	Control	7.1	194	1
	25 p.p.m.	6.9	179	2
	50 p.p.m.	6.0	165	3
Lane's Prince Albert ..	Control	3.8	14	29
	25 p.p.m.	2.5	4**	18
	50 p.p.m.	0.7	1**	5*
Lord Lambourne	Control	3.8	54	14
	25 p.p.m.	3.4	42	15
	50 p.p.m.	2.4	27	13
Worcester Pearmain ..	Control	5.7	60	28
	25 p.p.m.	4.3	75	9**
	50 p.p.m.	2.7	52	6**
Crawley Beauty	Control	6.3	69	29
	25 p.p.m.	3.7	18**	27
	50 p.p.m.	3.5	13**	27
Laxton's Superb "On" ..	Control	6.8	73	25
	25 p.p.m.	6.0	42	39
	50 p.p.m.	4.6	54	21
Laxton's Superb "Off" ..	Control	16.7	31	138
	25 p.p.m.	12.4	96	71
	50 p.p.m.	11.4	80	67

* Differs from control at 1% level of significance.
** „ „ „ „ 0.1% level of significance.

Crawley Beauty failed to show an increase in the marketable crop as defined above, but the effect of treatment was similar to that obtained in 1955. The smaller fruits were drastically thinned and both concentrations increased the number of fruits in the larger size classes. The mean fruit size of the crop, however, was larger in 1956 than in 1955 so that a significant increase in the number of large fruits becomes apparent only when fruits greater than $2\frac{1}{2}''$ in diameter are considered (controls, 25 and 50 p.p.m. gave respectively 3, 12 and 12 fruits $>2\frac{1}{2}''$ per 100 blossom clusters). Treatment again had little effect on Laxton's Superb " on-year " trees.

None of the other varieties used in the trial showed any increase in marketable crop. Miller's Seedling, Lane's Prince Albert and Lord Lambourne reacted to treatment in a manner intermediate between that of Crawley Beauty and Laxton's Superb : i.e. both concentrations resulted in an overall thinning, the effect being more pronounced on the smaller fruits. These varieties exhibited a marked difference in susceptibility to NAm, however, Lane's Prince Albert being the most sensitive and Miller's Seedling the least. Worcester Pearmain and Laxton's Superb " off-year " trees both showed a decrease in marketable fruit and no thinning of smaller fruits, but it is unlikely that any inconsistency exists between the effect of NAm on these and the other varieties, since the overall thinning has been masked by the persistence of very small fruits that have stopped growing but have not abscissed.

Further Observations on 1955 Trial.

Branches of Crawley Beauty and Laxton's Superb that had been used for the 1955 trial were lightly tip pruned in the winter 1955-56 and blossom records were kept in 1956. The branches of Laxton's Superb were in a completely "off-year" condition and carried no blossom. Those of Crawley Beauty all flowered in 1956, but those branches that had been sprayed with NAm the previous year blossomed more profusely than did the controls. At harvest, the fruit was weighed and graded by size groups. The number of fruits in each size group is shown in Fig. 1 as a percentage of the number of blossom clusters recorded in 1955. The corresponding figures for 1955 are given for comparison.

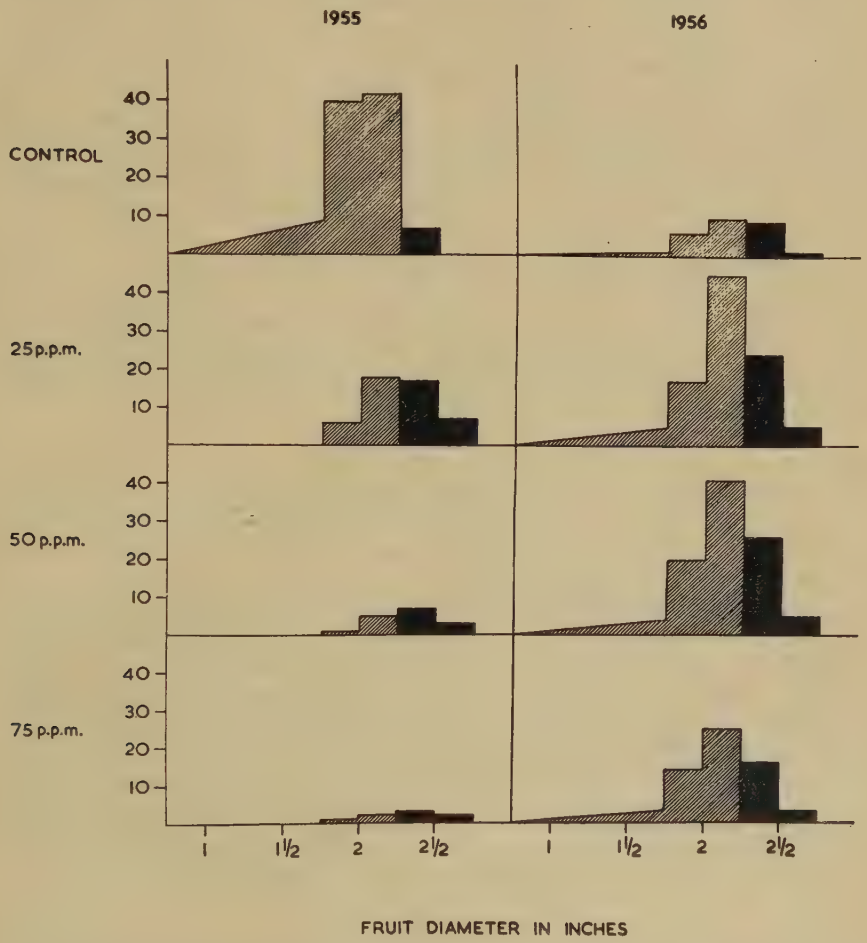


Fig. 1. Yield of fruits from Crawley Beauty in 1955 and 1956. Numbers of fruits in each size class are expressed as a percentage of the 1955 blossom clusters.

Although Crawley Beauty is generally regarded as a regular cropping variety, individual limbs tend to be biennial. It is clear from Fig. 1 that whereas control branches yielded only a small crop in 1956, branches sprayed

in the previous year yielded comparatively heavily, the marketable crops from branches sprayed at 25 and 50 p.p.m. being approximately three times, and from those sprayed at 75 p.p.m. approximately double, that of the controls. Aggregating the marketable crops of both years, the total yields of fruit $>2\frac{1}{4}''$ per 100 initial blossom clusters are :—

Control	17 fruits
25 p.p.m.	54 fruits
50 p.p.m.	42 fruits
75 p.p.m.	24 fruits

The increased yield from branches sprayed at 25 p.p.m., which is greater than the control yield at a 0.1% level of significance, is particularly notable. But since one effect of treatment has been a reversal of the biennial phase, control branches may be expected to carry a heavy crop in 1957 while that from treated branches will probably be light and the cumulative difference between the yields from control and treated branches will be reduced. But had branches treated in 1955 been sprayed again at 25 p.p.m. in 1956, one could reasonably expect an increased yield from them in 1957, and the gain in the 1956 marketable crop itself might have been still greater, for the residual effect of the spray has been to increase the overall yield rather than the proportion of large fruit as in the year of application.

In its ability to influence flowering and fruiting in the year following application, NAm stands in marked contrast to NAA. During the many trials in which the acid has been used at Long Ashton, it has never been observed to have any effect on biennial bearing. If the results reported above can be confirmed, NAm may prove to be of value for regulating the cropping of some biennial varieties.

Summary.

(1) 1-Naphthaleneacetamide was applied as an aqueous spray at concentrations of 25 and 50 p.p.m. to branches of Miller's Seedling, Lord Lambourne, Crawley Beauty, Worcester Pearmain, Lane's Prince Albert and Laxton's Superb 2 to 4 days after petal-fall.

(2) All varieties were thinned by the sprays, though a difference in susceptibility was noted, Laxton's Superb and Miller's Seedling being the least and Crawley Beauty and Lane's Prince Albert the most sensitive. Thinning tended to be more severe on the smaller fruits and Crawley Beauty was the only variety to show an increase in large fruits.

(3) Continued observation of trees sprayed in 1955 showed that NAm had no effect on the biennial bearing habit of Laxton's Superb but had a marked influence on that of Crawley Beauty. Branches of this variety that had been sprayed at 25 p.p.m. in 1955 carried a crop of marketable fruit approximately three times that of control branches in 1956.

Acknowledgments.

Thanks are due to the American Chemical Paint Company for the gift of the naphthaleneacetamide, and to Mr. G. M. Clarke for the statistical analysis of the results.

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FRUIT SET ON COX'S ORANGE PIPPIN IN RELATION TO SPRAY PROGRAMME.

By L. C. LUCKWILL.

Introduction.

Accounts have been given of the progress of a three year trial at Long Ashton designed to assess the relative performance of lime-sulphur and captan as post-blossom fungicides on the apple variety Cox's Orange Pippin (1, 2, 3). These accounts deal primarily with the effectiveness of the two spray programmes in controlling apple scab and mildew, though data on crop weights are given from which it appears that the substitution of captan for lime-sulphur in the post-blossom sprays has resulted in higher crop weights per tree.

Total crop weight is determined by the combined action of many different factors such as tree size, number of fruit buds, initial set of fruit, the extent of the " first ", " June " and subsequent drops, and mean fruit weight. The present report contains a detailed analysis, carried out in 1956, on certain trees in this trial with the object of discovering which particular factors were contributing to the differences in cropping of the trees under the two different spray treatments.

Methods.

The layout of the fungicide trial is described in the Annual Report for 1954 (1). Two sets of trees were used for the observations on fruit set, viz :

(1) 10-year old bush trees of Cox on M.II, planted at 24 ft. square in grass without fillers. The pollinating varieties were Winston and Laxton's Superb.

(2) 10-year old bush trees of Cox on M.IX at 12 ft. square in grass. These trees were " fillers " in a 24 ft. square plant of permanent trees on M.II. Pollinators were as for Group 1.

There were 8 trees in the first set and 16 in the second, of which half received lime-sulphur and the other half captan in both 1955 and 1956 ; the trees within each set were otherwise directly comparable as regards age and size, soil, distance from pollinators and other factors that might affect fruit set.

Records were taken by counting the numbers of fruit-buds, blossom clusters, blossoms or fruits on selected branches of the trees at approximately weekly intervals throughout the season. For the trees on M.II, 8 branches per tree were used and, for the smaller trees on M.IX, 4 branches per tree, the branches being evenly distributed on the south, east, north and west sides of each tree. Observations were confined to blossom clusters produced on two-year old wood, i.e. branches in their first fruit season. Altogether a total of 1281 clusters was individually recorded.

Spray programme.

All the trees in the experiment received one pre-blossom spray containing 1.5% lime-sulphur, and four post-blossom sprays containing either 0.75% lime-sulphur, or 0.075% captan, at the intervals shown in Fig.1. They also received a pre-harvest spray of 1-naphthalene acetic acid (10 p.p.m.) to reduce fruit drop. Full details of the spray programme will be found in this Report (p. 103).

TABLE I.

FRUIT-SET DATA FOR TREES RECEIVING LIME-SULPHUR OR CAPTAN.

Rootstock	M.II			M.IX		
Spray treatment	Lime sulphur	Captan	Sig. +	Lime sulphur	Captan	Sig. +
No. of fruit-buds (32 branches).	375	370	—	435	400	—
No. of blossom clusters as per cent. no. of fruit buds. ..	82.4	87.9	*	71.3	84.5	***
No. of blossoms per 100 blossom clusters.	594	604	—	576	581	—
Fruit set per 100 blossom clusters :—						
on June 12	196	232	—	92	137	—
on July 25	73	83	—	38	51	—
at harvest	60	77	—	28	45	—
" First drop " (up till June 12) as per cent. no. of blossoms..	67.0	61.3	***	84.1	76.5	***
" June drop " (June 12–July 25) as per cent. fruit set on June 12.	62.9	64.4	n.s.	58.4	63.0	n.s.
" Late drop " (July 25–harvest) as per cent. fruit set on July 25.	17.9	7.8	***	26.2	11.7	**
Mean fruit weight (lb.) ..	0.161	0.159	n.s.	0.189	0.207	n.s.
Mean crop per tree (lb.) ..	105	180	—	27	44	—

+ Significance : n.s.=not significant ; *=significant at 5% ; **=significant at 1% ; ***=significant at 0.1% level ; — =not analysed.

Results.

Fruit-bud development. The warm dry summer of 1955 was exceptionally favourable for fruit-bud formation in apples, and in the early spring of 1956 all the trees in this experiment were well furnished with fruit-buds, even on the maiden shoots. However, many of these fruit-buds, particularly those towards the base of the one-year wood, failed to develop into normal blossom clusters, either remaining dormant or giving rise to abortive clusters with one or two blossoms and no leaves. The percentage of fruit-buds that developed into normal blossom clusters is given in Table I, and it will be noticed that this percentage is significantly higher for those trees receiving captan than for those sprayed with lime-sulphur. At the time these observations were made the differential spray treatments for 1956 had not yet started ; this effect on fruit-bud development is therefore presumably a carry-over effect from the treatments received the previous year.

Fruit-drop. The rate of fruit-drop was measured as the number of fruits dropped during each weekly period expressed as a percentage of the total number of fruits or blossoms attached at the beginning of the week. The results are expressed graphically in Fig. 1. from which it will be seen that

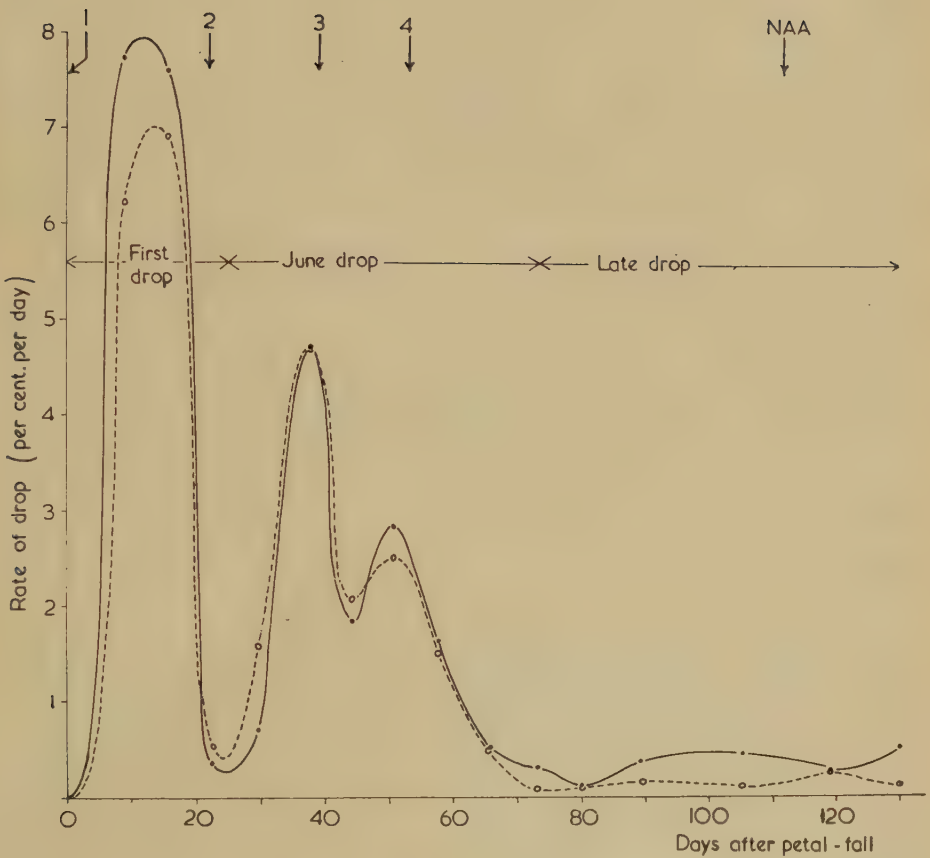

Fig. 1. Rate of fruit-drop from trees of Cox's Orange Pippin sprayed with lime-sulphur (continuous line) or captan (broken line). The numbered arrows indicate the date of application of the fungicidal sprays.

there were three well marked periods of drop. The " first drop ", which took place between 10 and 28 days after full-bloom, consisted of undeveloped and small developing fruitlets up to $\frac{1}{4}$ in. in diameter. The " June drop " occurred between 28 and 70 days after full-bloom and appeared to consist of two periods of rapid drop separated by a short interval of reduced abscission. After the end of the " June drop ", a continuous though low rate of fruit drop was maintained until harvest, 138 days after full-bloom ; this is referred to in the present paper as the " late drop ". Apart from this there was no marked " pre-harvest drop ", possibly because of the hormone spray applied on September 6th.

As may be seen from Fig. 1 and Table 1 the " first drop " was considerably greater from the trees sprayed with lime-sulphur than from those sprayed with captan, a difference which is highly significant (at the 0.1% level). The " June drop," on the other hand, did not differ significantly for the two groups of trees, though the " late drop " was again significantly greater where the spray programme included lime-sulphur.

Fruit-set. The fruit-set data (Table 1) are of necessity complementary to those of fruit-drop. They show that the main difference in cropping between the two groups of trees was already established as early as June 12th, at the end of the " first drop." By harvest time the trees sprayed with captan were carrying 17 more fruits per 100 blossom clusters than were those sprayed with lime-sulphur. For the trees on M.IX this represented an increase of over 60%, whilst for trees on M.II the increased set was 28%.

Fruit-size. No significant differences in fruit size, measured as average weight per fruit, were found between the two groups of trees.

Discussion.

It has long been realized that Cox is a partially sulphur-shy variety and that post-blossom applications of lime-sulphur at strengths exceeding 1% may induce partial defoliation and shedding of fruitlets. At $\frac{3}{4}$%, however, obvious symptoms of spray damage are seldom seen, and for many years lime-sulphur sprays of this strength have been the standard method of controlling apple scab. Only with the advent of newer fungicides, such as captan, has it become possible to get some basis of comparison on which to assess accurately the effect of these dilute lime-sulphur washes on the cropping of the tree, since comparisons with unsprayed trees, invariably infested with scab and mildew, are obviously not valid. The crop records for this trial (1, 2, 3), together with the data in the present paper, suggest that, even at concentrations as low as $\frac{3}{4}$%, lime-sulphur may cause a very appreciable reduction in fruit-set in Cox's Orange Pippin. Moreover, since this fruit-thinning action is not accompanied by any compensatory increase in the size of the remaining fruits, the reduced fruit-set is reflected directly in loss of crop, the loss in 1956 being of the order of 40% of the crop borne by the trees receiving captan.

From the physiological viewpoint it is interesting that the effects of lime-sulphur in reducing fruit set result chiefly from an increased " first drop " of small fruitlets, and to a lesser extent from an increased " late drop," whereas there appears to be no specific action on the intermediate " June

drop." A further factor which in 1956 contributed to the reduced cropping of the trees receiving lime-sulphur was the smaller proportion of fruit-buds that developed into normal blossom clusters ; this was evidently a residual effect of the sprays received the previous year.

Regarding the physiological mechanisms through which lime-sulphur exerts its effects on fruit-bud development and fruit-set little can be said at the moment. It is known from the work of Hoffman (4, 5) that lime-sulphur sprays may appreciably reduce the net assimilation rate of apple leaves, and it may be that the observed effects on cropping are the result of a lowered carbohydrate status, an effect which might be expected to be cumulative from year to year. On the other hand, the specific effects of lime-sulphur on the abscission process in leaves and fruits, particularly in sulphur-shy varieties, strongly suggest that it is interfering in some way with the auxin metabolism of the tree. With the aid of recently developed techniques for the extraction and estimation of auxins in apple leaves and fruits (6) it should now be possible to put this hypothesis to the test.

Summary.

(1) Previous work had shown that apple trees of the variety Cox's Orange Pippin receiving post-blossom sprays containing 0.75% lime-sulphur usually cropped less heavily than comparable trees receiving 0.075% captan.

(2) The reduced cropping in 1956 of trees sprayed with lime-sulphur in 1955 and 1956 was shown to be due to :—
  (a) The failure of a higher percentage of fruit buds to develop into normal blossom clusters.
  (b) An increased "first drop" of undeveloped flowers and small fruitlets.
  (c) An increased "late drop" (July 25th till harvest).

(3) There were no significant differences in the extent of the "June drop", or in final fruit size, attributable to the different spray programmes.

(4) The effect of lime-sulphur in reducing fruit set was relatively greater for filler trees on M.IX than for permanent trees on M.II.

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FRUIT DROP IN BLACK CURRANTS: III. THE EFFECT OF 1-NAPHTHALENE ACETIC ACID APPLIED BEFORE HARVEST.

By L. C. LUCKWILL, MARGARET E. KIESER and A. POLLARD.

Introduction.

In this country black currants in commercial plantations are always picked by the strig. Since the berries at the base of the strig may ripen as much as one to two weeks before those at the apex, the choice of picking date is of critical importance : if picked too early, the sample will contain an undue proportion of green and red berries which will reduce its commercial value, and, since many of the berries will not be fully grown, total crop weight will be below optimum. If on the other hand picking is delayed too long, many of the large berries at the base of the strig will drop, either before or during picking, again leading to a loss in crop weight. In practice a compromise is necessary and most commercial crops are picked as soon as the basal berries show a tendency to drop. At this stage the crop may still contain 30 to 40 per cent. of immature berries.

If the abscission of the basal berries could be retarded it might then become possible to delay picking for a sufficient time to allow the apical berries to develop to maturity, thus increasing both the weight and the quality of the crop. It was to investigate this possibility that the present experiment was designed. 1-naphthalene acetic acid (NAA), the growth regulator that is used to delay pre-harvest drop in apples and pears, was applied to fruiting bushes shortly before the normal harvest date, and picking was then delayed for a period of six days. Observations were made on the effect of delayed picking, and of the hormone treatment, on crop weight and quality.

Methods.

Lay-out of experiment. Vigorous bushes of the variety Mendip Cross in their first fruiting season, planted at 8 × 3 ft., were used for the experiment. The experimental unit was one row of 112 ft., containing approximately 38 bushes. Altogether there were 16 such unit plots, allowing four replicates of each of four treatments, the whole experiment being laid out in a randomized block design. The four treatments were as follows :—

A = picked at normal harvest date (July 10th).
B = untreated, but picked 6 days later than normal.
C = sprayed with NAA 10 p.p.m. and picked 6 days later than normal.
D = sprayed with NAA 25 p.p.m. and picked 6 days later than normal.

The hormone sprays were applied on July 6th, four days before the normal harvest date, using a small power sprayer with a single nozzle lance. The bushes were sprayed to run-off, particular care being taken to wet thoroughly the fruiting branches. The day was sunny with a shade temperature of 21°C. at the time of spraying. There was no appreciable drift of spray across the rows.

Sampling. The crop was picked into 4 lb. chip baskets and was sampled immediately after picking by taking 12 complete strigs of fruit at random from

each basket. This gave a total sample of approximately 200 strigs per plot, half of which were used for the determination of stage of ripeness, and the remainder for juice analysis and ascorbic acid determinations.

Stage of ripeness was assessed by removing the berries from the strigs and sorting them into three categories, viz : (1) over-ripe (burst or shrivelled) ; (2) ripe ; (3) under-ripe (red or green) . The number and weight of berries in each category was recorded. Records were also taken of the total weight of crop from each of the experimental plots.

Ascorbic acid determination. Berries were removed from the strig and weighed out into 50 g. samples which were sealed in cellophane bags and stored at -23°C. for later analysis. After three weeks storage the samples were extracted with metaphosphoric acid in a Waring blendor and, after coarse filtration, were made up to give a final volume of 500 ml. in 3 per cent. metaphosphoric acid. Aliquots of this solution were titrated with dichlorophenolindophenol using the potentiometric method of Liebmann and Ayres (1) as modified by Curtis (2).

Juice analysis. Samples for juice analysis were taken by combining fruit from the four replicate blocks in each treatment. Immediately after picking, the fruit was crushed and treated with 0·5 per cent. Pectozyme at 40°C. for 3 hours and the juice pressed out. Specific gravity and titratable acidity were determined.

TABLE I.

EFFECT OF DELAYED HARVESTING AND TREATMENT WITH NAA ON CROP WEIGHT AND FRUIT QUALITY OF BLACK CURRANT, VAR. MENDIP CROSS.

(Means of 4 Plots—1956).

Group	A	B	C	D
Treatment	None	None	NAA 10 p.p.m. 6/7/56	NAA 25 p.p.m. 6/7/56
Picking Date	10/7/56	16/7/56	16/7/56	16/7/56
No. of bushes	149	147	149	150
Mean crop per bush (lb.)	2·38	2·85	2·89	2·55
Under-ripe berries % by number ..	43·8	10·9	10·5	8·4
Over-ripe berries % by number ..	2·7	23·3	25·6	30·5
Ascorbic acid mg./100 g.	166	154	152	142
Sp. Gr. of Juice	1·051	1·060	1·060	1·059
Acidity (% citric)	3·44	3·47	3·33	3·32

Results.

The results of the experiment are summarized in Table I and are discussed below.

The effect of delayed harvest. Treatment A, picked at the normal harvest date, was an average commercial sample. At the time of picking there had been no appreciable berry drop and only a very low proportion of fruit was classified as over-ripe. There was, however, a high proportion (43·8 per cent. by number)

of green and red berries in the sample. This sample of fruit showed the highest ascorbic acid concentration, but the lowest sugar as shown by the specific gravity of the juice.

The most striking effect of delaying harvest by 6 days (Treatment B) was an increase in crop weight of 21 per cent. This increase, which was of the order of ½ lb. per bush, was of high statistical significance (0·1%) and probably resulted from the continued growth of the immature berries near the apex of the strig. The advance in maturity during the 6 days is clearly shown by the change in the percentages of under-ripe and over-ripe berries as compared with sample A. The increased ripeness is also reflected in an increase in the sugar content of the juice. The ascorbic acid concentration is significantly lower (at 1%) than in sample A but, owing to the greater crop weight, the yield of ascorbic acid per bush is actually higher than in the sample picked at the normal time.

In this particular season there was little dropping of berries even when harvest was delayed for six days. Instead, the basal berries remained attached to the strig and burst, so that commercially the sample was of low quality.

The effect of NAA. NAA at 10 p.p.m. applied four days before the normal harvest date had very little effect, either on the weight of crop, the stage of ripeness or on the ascorbic acid and sugar content of the juice. The titratable acidity alone appeared somewhat lower than in the untreated sample (B) picked on the same day. At 25 p.p.m. NAA resulted in a marked stimulation of ripening which was reflected in a higher percentage of over-ripe berries and a lower ascorbic acid content. The total yield was also reduced in this treatment, probably as a result of the bursting and subsequent shrivelling of many of the largest berries at the base of the strig. Neither concentration of NAA caused any appreciable damage to the bushes.

Discussion.

The absence of any pre-harvest dropping of berries in 1956 prevented the assessment of the value of NAA as a drop control agent, which was the primary purpose of the experiment. With some varieties, and in some seasons, a delay of a week in harvest can result in very heavy crop losses due to berry drop, but in this experiment there was actually an appreciable increase in crop as a result of delayed harvest. However, the experiment has revealed another effect of NAA when applied at a concentration of 25 p.p.m., namely its ability to stimulate ripening of the berries. A similar effect has been noted with certain early varieties of apples. Whilst this ripening effect would be a disadvantage if NAA were used to control berry drop, it might be turned to good advantage where it was desired to spread the picking season of the crop. By spraying somewhat earlier than was done in this experiment it might prove possible to advance maturity by at least several days.

This experiment has also confirmed the inverse correlation between the degree of ripeness, as measured by the percentage of over-ripe berries in the sample, and the ascorbic acid content of the juice. This is well illustrated in Fig. 1 in which the ascorbic acid concentration in each of the 16 samples (4 treatments × 4 replicates) is plotted against the percentage of over-ripe berries.

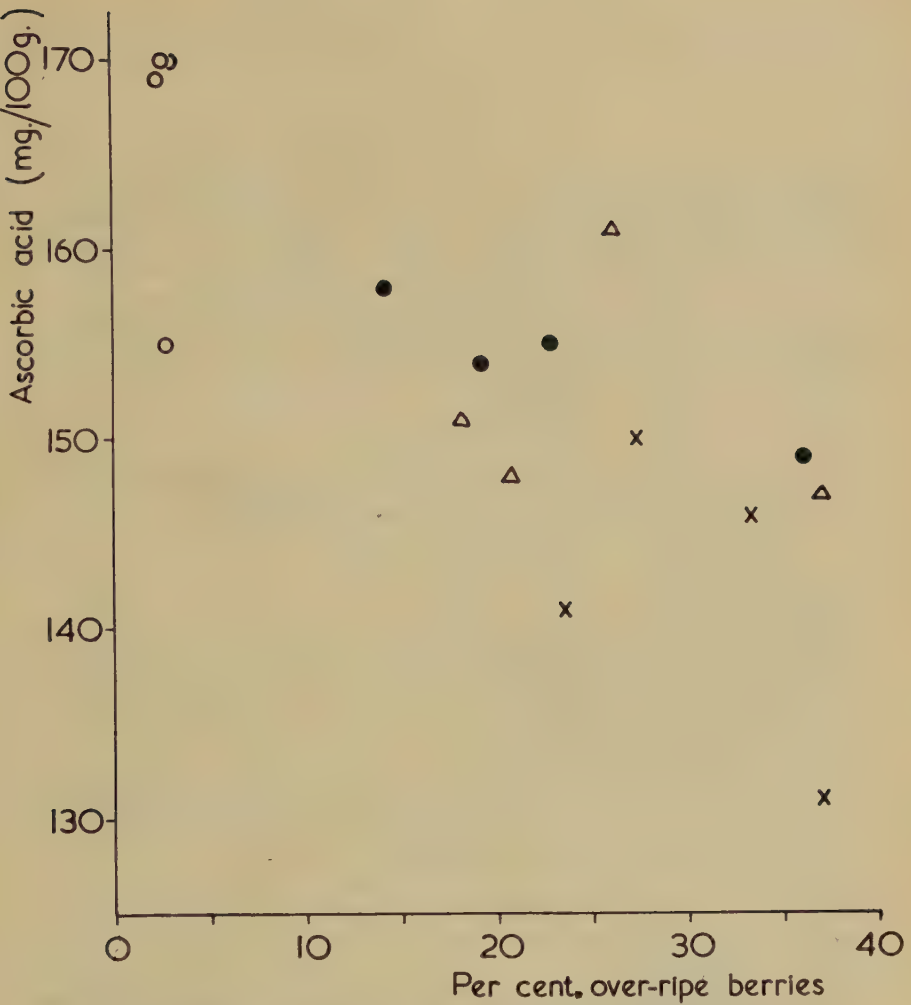

Fig. 1. Correlation diagram showing relationship between stage of ripeness of sample and ascorbic acid content of juice. Black currant *var.* Mendip Cross, 1957.

O = Normal harvest date (A);
● = Harvest delayed 6 days (B);
Δ = NAA 10 p.p.m. plus delayed harvest (C);
X = NAA 25 p.p.m. plus delayed harvest (D).

Summary.

(1) By delaying picking for six days beyond the normal harvest date the total crop weight of young bushes of Mendip Cross black currant was increased by 21 per cent. However, the quality of the fruit was reduced, 23 per cent. of the berries being over-ripe. The ascorbic acid content of the juice was also significantly less than that of fruit harvested at the normal time.

(2) The application of l-naphthalene acetic acid at 10 p.p.m. four days before the normal harvest date had little effect on crop weight or quality when harvest was delayed for six days. At 25 p.p.m. the same compound resulted in a marked stimulation of ripening and in a reduced yield.

(3) A marked negative correlation was observed between the degree of ripeness of the fruit, as measured by the percentage of over-ripe berries, and the ascorbic acid concentration in the juice.

Acknowledgments.

The authors wish to acknowledge the help of Mr. P. S. Weaver and Mr. E. Catlow, who supervised the harvesting, Mr. C. W. Harper and Mr. H. R. Mapother, who applied the experimental sprays, and Mr. D. J. Sissons, who assisted with the laboratory determinations. They also thank Mr. G. M. Clarke for carrying out the statistical analysis of the data.

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THE PROPAGATION OF GOOSEBERRIES: IV. SOFTWOOD CUTTINGS.

By BARBARA A. RAKE.

Introduction.

While a gooseberry bush produces a large number of new shoots each year, only a small proportion of these attain sufficient length for use as hardwood cuttings. It was thought that the less vigorous shoots might be utilized for propagation by softwood cuttings in the summer by a method that would be useful where it was desired to build up rapidly a large stock of planting material from a very limited supply of parent bushes. An experiment was therefore carried out in which four different methods of preparing the cuttings were examined at four planting dates.

Experimental.

The cuttings were rooted in a double cold-frame in a compost containing approximately 2 parts loam, 1 part peat, 1 part Cornish grit. The area between the inner and outer frames was filled with peat soaked to full capacity with water in order to maintain humidity.

After the cuttings were planted, framelights, shaded with "Summer Cloud", were placed lengthwise along the inner portion of the frame; on top, further lights were placed in the normal manner over the whole frame. Sulphur dusting was carried out after planting to control damping off. The variety was Keepsake.

The types of cuttings used were as follows:—

(a) Basal cutting cut flush with junction of last year's wood. 2″ of base cleaned of leaves, cut made above two remaining leaves at top.
(b) As (a), but with the lower buds removed leaving two only, with subtending leaves, at the top.
(c) Apical cutting, prepared from the growing tip of the shoot, 3″ long; the lower 2″ cleaned of leaves.
(d) As (c), but with the buds on the lower 2″ removed (Plate III).

The four planting dates were as follows:—

PLATE III.

Terminal cutting.

Basal cutting.

May 21—When shoots on the parent bushes were about 6″ long and were growing actively; lignification had not yet started at the base of the shoot.

June 8—When shoots were still expanding at the tips; lignification at the bases of the shoots had commenced.

June 28—When growth at the tips of the shoots was about to cease. Lignification of the shoots had reached about halfway.

July 29—Growth had ceased. A few shoots were entirely lignified.

The trial was laid out as a factorial experiment in two blocks, giving eight replicates for planting time, sixteen replicates of the effect of buds, and sixteen replicates of the effect of the part of the shoot used as a cutting.

The shoots had their bases placed in water as soon as they were removed from the bush. The cuttings were prepared, and planted in the frame immediately, 2-3″ apart in rows 6″ apart. Each plot consisted of twelve cuttings, ten of which were recorded, the two end ones being guards. Guard rows were planted also at the two ends of the frame.

TABLE I.

FACTORS INFLUENCING THE PERCENTAGE TAKE OF SOFTWOOD CUTTINGS OF GOOSEBERRY *var.* KEEPSAKE.

Treatment	Number of cuttings	% rooting	Significance of differences
Type of cutting			
A — Basal with buds ..	96	54	(see under)
B — Basal without buds	96	43	
C — Apical with buds ..	96	11	
D — Apical without buds	96	20	
Part of shoot used			
Basal	192	48	P>0·01%
Apical	192	16	
Effect of buds			
Lower buds removed ..	192	31	Not significant
Lower buds not removed	192	33	
Planting date			
May 21st	96	37	Not significant
June 8th	96	37	
June 28th	96	31	
July 9th	96	21	

After planting, all the cuttings dropped their leaves and growth recommenced from the axillary buds.

It appeared that early planting, before growth had ceased and lignification set in, gave the best results, though actual differences between planting times were not significant.

The removal of the lower buds had no effect on the percentage of cuttings rooting.

Basal cuttings gave significantly (P>0·01%) better results than terminal ones.

In only four of the treatments did more than 50% of the cuttings " take ", and although this is more than is often obtained with hardwood cuttings by some nurserymen, it cannot be considered exceptionally good.

It was necessary to line out the cuttings in nursery rows for a further growing season before they were equivalent in size to a normal one-year-old rooted hardwood cutting. In practice this would not mean losing a year as the cuttings would have reached the same size at the same time as hardwood cuttings taken from the equivalent shoots during the following winter. Neither would extra labour be involved in this procedure, as hardwood cuttings are normally lined out for a year before planting permanently. Softwood cuttings lined out for two seasons would thus reach the planting stage at the same time as the hardwood cuttings, having been taken from the parent bush four months earlier.

Summary.

An experiment was carried out to examine the effect of type of cutting and planting time on the "take" of softwood cuttings of gooseberry, *var.* Keepsake.

Cuttings prepared from the basal portion of new shoots rooted significantly better than those prepared from the tips. The removal of buds had no effect on the percentage "take". Early planted cuttings (May) appeared to root better than those planted later (July), but the difference was not statistically significant.

Acknowledgment.

Thanks are due to Mr. G. M. Clarke for the statistical analysis of the results; to Mr. J. Clarke for the construction of the frame and care of the cuttings, and to Mr. G. Jones for the photograph.

THE PROPAGATION OF GOOSEBERRIES: V. LAYERING.

By BARBARA A. RAKE.

Introduction.

Layering is a method which is seldom recommended for propagating gooseberries. Oldham (1) mentions its possible use when material is scarce, but states that the resulting bushes are rarely of good shape. The recommended method is to peg down the lower shoots and cover them with soil.

Nevertheless the use of layering as a means of propagating gooseberries, if it can be made to give successful results, may show several advantages over the more common method of using hardwood cuttings. Since the shoot is not detached from the parent plant until after it is rooted, rooting is quicker and survival more certain. Whereas it takes a year from the time of planting a hardwood cutting to the lifting of the same cutting when rooted, a shoot layered in July produces a plant which can be lifted and planted out within three months.

Several variations in methods of layering are practised by nurserymen according to the type of plant. Blackberries and allied fruits can only be layered by burying the tip of a growing shoot; little success is obtained by burying the older shoots or by laying them along the surface of the ground. Very many shrubs are layered by making an upward incision into the bark and part of the wood on the underside of a shoot, which is then buried or pegged firmly on to the surface of the soil. With other shrubs (e.g. Heaths) the older portions of the shoots are simply buried in the soil without previously making an incision.

This paper reports the results of a trial in which five different methods of layering gooseberries were compared.

Experimental.

The layering treatments were as follows :—

(a) The tip of the growing shoot was bent down and buried 2″ deep in the soil.
(b) The growing shoot was sliced upwards for 1″ on the underside just penetrating the wood at a point about 3″ from the growing tip. The shoot was laid along the surface of the ground and pegged firmly down at the point of incision.
(c) The shoot was laid as in treatment (b) but without previous incision.
(d) The shoot was prepared with incision as in treatment (b), and then pegged firmly down in a small depression in the soil at the point of incision and buried, covering 2″ of the stem. The tip of the shoot was left uncovered.
(e) The shoot was laid and buried as in treatment (d), but without previous incision.

TABLE I.

COMPARISON OF FIVE DIFFERENT METHODS OF LAYERING GOOSEBERRIES.

Treatment		Number of shoots layered	Number of layers forming roots	Number of survivals after 1 yr. in nursery	Mean root category when lifting from layer bed	Mean vigour category after 1 yr. in nursery
A	Leveller	6	5	4	7·6	9·2
	Careless	9	9	8	3·9	7·0
	Total	15	14	12	5·8	8·1
B	Leveller	6	4	4	4·8	4·3
	Careless	9	7	5	1·0	5·7
	Total	15	11	9	2·9	5·0
C	Leveller	6	5	5	8·0	4·0
	Careless	9	6	5	1·7	7·3
	Total	15	11	10	4·9	5·7
D	Leveller	6	6	5	8·3	2·2
	Careless	9	6	4	4·7	6·0
	Total	15	12	9	6·5	4·1
E	Leveller	6	6	6	9·7	7·8
	Careless	9	9	8	4·4	6·2
	Total	15	15	14	7·1	7·0

Three-year-old bushes of Leveller and Careless were used and these were planted out in three blocks of ten bushes each. Two shoots were layered on each Leveller and three on each Careless bush. The shoots were layered during the first week in July and were lifted and re-planted in nursery rows during the last week in October.

Records were made at the time of lifting of the number of layers which had formed roots, and the amount of root on each layer was recorded in categories 1-10. The number of bushes surviving, and their vigour, was recorded after the layers had been grown on for one year in the nursery.

Results.

Table I gives the results of root formation and subsequent behaviour for the different treatments.

Treatment (a) gave fairly good results with Leveller for initial rooting and vigour, and for subsequent behaviour. Careless tended to throw axillary shoots above the buried tip instead of forming many roots, but these layers developed into bushes of satisfactory vigour in one year from planting out in nursery rows. In both varieties, however, the shape of the resulting bushes was poor since on lifting the layer the stem was naturally inverted. A normal shoot did not grow out until the following year, and was sucker-like in character (Plate IV (*a*) and (*b*)). While this method might be satisfactory for starting stool bushes it is doubtful whether a bush of a good shape on a " leg " could ever be formed satisfactorily.

Treatment (b) gave poor results with both varieties. It is probable that the incision, without protection of the soil, allowed too severe drying out of the shoots.

Treatment (c) gave good results with Leveller for initial rooting, but vigour was poor after a year in the nursery rows. The reverse occurred with Careless ; rooting was very poor initially, but subsequent behaviour improved markedly.

The shape of the bushes resulting from layering by treatments B-E was more satisfactory than those produced by tip layering. An upright shoot grows up from the layer during the rooting process, and this can be trimmed and disbudded to form a " leg ", and the foundation for a good head, at lifting time (Plate V).

With both varieties treatment (d) gave better initial rooting than treatment (c), roots being produced over a longer length of stem (Plate IV (*c*)). Subsequent behaviour in the nursery, however, was not as satisfactory as treatment (c).

Treatment (e) gave excellent initial rooting with Leveller, while Careless, although it did not root so well at first, improved after being planted out for one year in the nursery.

Discussion.

Although gooseberries may be readily propagated by layering, and well-shaped bushes can be produced, it is doubtful whether the method has an advantage over hardwood cuttings when large quantities of material are required. The number of shoots layered per bush in this experiment was small,

(*a*) Layer rooted from buried tip, lifted three months from planting. Bud A will grow out to form a sucker-shoot.

(*b*) Layer (*a*) after growing for one year in nursery. Bush is of poor shape.

(*c*) Layer rooted from stem laid under soil with tip exposed. Longer area of rooting than layer in Plate V (*a*).

(*a*) Layer rooted by treatment C. Before trimming at lifting time.

(*b*) Same layer trimmed and dis-budded ready for planting in nursery.

(*c*) Same layer after growing for one year in nursery. Compare improved shape with Plate IV (*b*).

due to scarcity of suitable parent material ; normally, however, a considerable number of shoots (2-3 dozen) are suitable for layering on a mature gooseberry bush. Although by layering a large amount of root can be produced on a shoot within a very short period, the roots are coarse and fleshy and of a different character from those produced by hardwood cuttings. On layered cuttings the amount of root does not appear to correspond with the vigour of growth during the following growing season. In fact the results show that growth following planting out tends to be in inverse proportion to the amount of roots present on the layer when lifted. Consequently little, if any, advantage in time is gained by layering as opposed to propagation by hardwood cuttings.

Although not to be recommended for general use, propagation by layering may be of value in special circumstances, particularly for varieties that will not readily root from hardwood cuttings.

Summary.

Five methods of layering were tested on the gooseberry varieties Leveller and Careless. The amount of root formed and subsequent behaviour after planting out were noted.

Tip layering resulted in bushes of unsatisfactory shape. Incision of the underneath portion of the stem before layering did not improve results. Best results were obtained from shoots layered by burying a 2″ portion in the soil, leaving 2″ of the growing tip uncovered. The resulting bushes were well-shaped.

Leveller produced more shoots on the layer than Careless but Careless produced more vigorous bushes than Leveller after one year in the nursery.

Acknowledgment.

Grateful thanks are due to Mr. G. Jones for the photographs.

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COVER CROPS IN RELATION TO SOIL FERTILITY AND TREE NUTRITION: II. AN EXPERIMENT WITH DESSERT BUSH APPLE TREES: PROGRESS REPORT I.

By C. BOULD and R. M. JARRETT.

A previous experiment on established bush cider apples (1, 2, 3) indicated that cover crops had a significant effect on the mineral nutrient status of apple leaves; in particular, that leaves from trees growing under a regularly cut grass cover contained higher concentrations of potassium and phosphorus, and a lower concentration of nitrogen, than leaves from trees growing under arable conditions or annual cover crops. Although the yields of fruit from trees growing under grass cover were generally higher than those from trees under arable culture, the differences were not statistically significant (the trees were already 12 years old when the covers were sown and the precision of this experiment was low because of the small number of replications). It was decided, therefore, to repeat the experiment on young dessert apple trees, using an improved layout to determine: first, the effect of various cover crops and fertilizer treatments on soil fertility, tree growth, crop yield, fruit quality and leaf nutrient status; secondly, the relationship between leaf nutrient status and tree performance, and thirdly, the botanical changes in the cover crops induced by time and fertilizer treatment.

This report covers the five-year period after the trees were planted as maidens in 1952, and describes the initial effects of the cover crops on tree growth and on leaf nutrient status.

Experimental.

Site and Soil.

The site is fairly level and rather exposed to the prevailing west wind. Until 1948 it had been under continuous arable culture for about 30 years; for the last 20 years as a plum orchard. During 1948-49 the plum trees were removed and vegetable crops were grown for two seasons; these crops received nitrogenous fertilizer only. The whole area was fallowed in 1951 prior to planting with maiden trees in 1952.

The soil is a reddish-brown heavy sand (Series No. 6 as classified by Osmond (4)). Chemical data pertaining to main plot samples are given in Table I.

Material.

Three apple varieties, Cox's Orange Pippin, Worcester Pearmain and Bowden's Seedling, all on Malling II rootstock, were planted in February 1952, on a 20′ square plant, with consecutive rows of each variety running N-S. Two varieties only were used for recording purposes, the third variety, Bowden's Seedling, forming the N-S buffer rows.

Layout and treatments.

The design is a replicated randomized block with split plots, giving four-fold replication of the main plots (covers) and eight-fold replication of the sub-plots (fertilizers), the N × P × K × cover interaction being confounded with the sub-blocks; as a consequence, N × P × K interaction is also partially confounded. A main plot consists of eight recorded trees, four Cox and four Worcester, and includes four sub-plots. A sub-plot contains only two recorded trees, one of each variety, and is buffered on all sides by guard trees.

TABLE I.

CHEMICAL ANALYSIS OF SOILS PRIOR TO MANURING.
(Means of 4 plots as % air-dry soil. Sampled March 1956).

Soil constituent	Depth	Treatments				
		W White clover	*X* Rye grass	*Y* Timothy grass	*Z* Tumble down	Arable
Organic carbon	0–6″	1·77	1·76	1·85	1·72	1·66
„ „	6–12″	1·04	1·12	1·01	1·09	0·96
Exchangeable K ..	0–6″	0·0165	0·0168	0·0157	0·0155	0·0173
„ „ ..	6–12″	0·0109	0·0111	0·0100	0·0103	0·0114
Exchangeable Mg ..	0–6″	0·0035	0·0031	0·0033	0·0030	0·0064
„ „ ..	6–12″	0·0028	0·0026	0·0026	0·0025	0·0046
N/2 Acetic acid-sol. P ..	0–6″	0·0039	0·0041	0·0043	0·0038	0·0038
„ „ „ „ „ ..	6–12″	0·0019	0·0014	0·0013	0·0014	0·0012
pH. (Soil:water, 1:2·5) ..	0–6″	7·6	7·7	7·6	7·7	7·1
„ „ „ „ ..	6–12″	7·5	7·7	7·7	7·6	7·1

Main plots (*covers*). These were sown in April 1955 at the following rates :—

Symbol	*Cover*	*Rate of seeding*
W	White clover, S.184	3 lb. per acre
X	Perennial rye grass, S.23	16 lb. per acre
Y	Timothy grass, S.50	8 lb. per acre
Z	Tumble down	(natural sward, not seeded)

Sub-plots (*fertilizers*). There are eight fertilizer treatments (NPK factorial) superimposed on the main plots as combination (a) or (b) :

(a) N ; P ; K ; NPK. (b) NP ; NK ; PK ; Nil

The fertilizers were first applied in March, 1956, and were broadcast over the sub-plots at the following rates :—

N as Nitro-chalk at 2 cwt. per acre (15%N)
P as superphosphate at 3 cwt. per acre (18%P_2O_5)
K as potassium sulphate at 1 cwt. per acre (48%K_2O)

In addition to the above treatments the whole cover crop area receives a general dressing of Nitro-chalk at 2 cwt. per acre each spring.

Although not part of the main experiment, one complete replicate of the fertilizer series (8 treatments) is applied annually to an adjacent block of trees maintained under arable culture. The over-all spring dressing of Nitro-chalk is not given to these trees and, furthermore, the N level is reduced from 2 to 1 cwt. Nitro-chalk per acre.

Management.

Prior to 1955 the plot was cultivated during the spring and summer months, weeds being allowed to grow during the autumn. After the establishment of the cover crops frequent gang-mowing was carried out, the frequency being governed by the growth of the clover. All cover crops received the same number of cuts and the herbage was allowed to decompose *in situ*.

Pruning has been designed to produce a delayed open-centre bush tree. Much lateral wood has been retained with the aim of producing a large tree quickly. De-blossoming was carried out from 1952-1955. Owing to the dry period in 1956 it was decided to de-fruit in that year, except on the arable block adjoining the main experimental area.

Routine spraying was carried out for pest and disease control. Lime sulphur was used pre-blossom and captan for post-blossom control of scab. Magnesium deficiency was controlled in 1953 and 1954 by foliar sprays of 2% Epsom salts, but the sprays were discontinued in 1955 in order to study the effect of cover crops on leaf nutrient status.

Results.

Botanical composition of swards.

A summary of a botanical analysis of the swards made in August 1956, under the supervision of Dr. L. C. Luckwill, is given in Table II.

TABLE II.

PERCENTAGE FREQUENCIES OF THE DOMINANT SPECIES, AUGUST 1956.
(Each frequency is based on 1,600 throws of a 5 × 5 cm. quadrat).

Species	Cover crop			
	W. Clover	Perennial rye grass	Timothy	Tumble down
Trifolium repens ..	99·1	11·2	7·8	9·5
Lolium perenne ..	16·7	98·9	3·6	8·0
Phleum pratense ..	5·6	0·9	99·4	10·7
Poa annua	90·1	52·2	89·0	99·0
Agrostis stolonifera	2·5	4·5	8·6	28·5
Other species ..	7·1	6·5	7·6	26·2

It is clear from Table II that the sown species were well established in the year following seeding. On " tumble down " plots *Poa annua* was the dominant species with a fair proportion of *Agrostis stolonifera* (an indigenous species). *Poa annua* was a serious contaminant on all plots. Fertilizer treatments, applied in March, had no significant effect on the composition of the swards as measured in August of the same year.

It was noticed that the botanical composition of the sward in any plot was markedly influenced by that of the adjacent plots, possibly due to seed scatter at the time of sowing, or to movement of seed by subsequent harrowing and rolling. This edge effect, however, is unlikely to affect the recorded trees for many years.

Growth index.

Trunk diameters have been recorded annually during the dormant season as the mean of two measurements made at right angles to each other at a fixed height above ground. Analysis of these data showed that in the pre-treatment years the variance for Cox's Orange Pippin decreased with increasing age of tree, whereas that for Worcester Pearmain increased for the first two seasons, but by the winter of 1954/1955 the variance for both varieties had reached a steady level.

Analysis of variance of the proportional increase in girth (i.e. 1956 girth divided by 1954 girth) has been compared with the standard co-variance method and found to give the same significant differences and to be considerably less complicated. Transformation of actual girth measurements to logarithms, prior to analysis, has been shown by Pearce (5) to be the most satisfactory method for this type of data and has been adopted in the present studies.

The first year of cover cropping, i.e., prior to the addition of fertilizers, had no significant effect on the proportional increase in girth, but significant effects had been produced by the end of the second season : these effects are shown in Table III. Girth increase of trees on the clover and tumble down plots was considerably greater than that of trees on the timothy and rye grass plots, but less than that of trees on the arable plots.

TABLE III.

PROPORTIONAL INCREASES IN TRUNK GIRTH 1956/1954 AS LOGARITHMS.

(Mean values for 16 trees).

Treatments	Cox				Worcester			
	log. P.I.	Sig. diff. 1%	Sig. diff. 5%	Comparisons for 1% P	log. P.I.	Sig. diff. 1%	Sig. diff. 5%	Comparisons for 1% P
W. W. clover ..	0·189	0·024	0·017		0·160	0·026	0·018	
X. P. rye ..	0·102	„	„	W,Z>Y>X	0·098	„	„	W,Z>Y,X
Y. Timothy ..	0·130	„	„		0·110	„	„	
Z. Tumble down	0·182	„	„		0·148	„	„	
Arable ..	0·234	—	—	—	0·227	—	—	—

Fruit-set, 1956.

Owing to the dry period early in 1956 (see Table IV) and its adverse effect on the growth of trees under cover crops, it was decided to remove in June all fruits except those from trees on the arable plots. The numbers of fruits per tree are recorded in Table V. It will be seen that the trend is the same for both varieties, and follows that of the leaf nitrogen (see Fig. 1), poor set being associated with low leaf nitrogen. The differences are significant only for the variety Worcester Pearmain.

TABLE IV.

ANNUAL DISTRIBUTION OF RAINFALL.

(inches)

Year	Month												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Mean 1914-1954	3·37	2·58	2·33	2·33	2·59	2·11	3·16	3·65	3·15	3·85	3·70	3·57	36·39
1955	3·38	1·78	1·27	1·42	3·91	2·59	0·15	0·64	1·34	1·42	4·22	3·76	25·88
1956	4·01	0·20	0·99	1·92	0·50	2·78	4·26	7·99	3·46	1·40	1·07	4·12	32·70

TABLE V.

MEAN NUMBER OF FRUITLETS PER TREE, JUNE 1956.

Cover crop	Cox		Worcester			
	Fruit set	Sig. diff.	Fruit set	Sig. diff. 1%	Sig. diff. 5%	Comparison
W. White clover ..	81		43			1% P.,
X. Rye grass ..	52	N.S.	13	25	17	Z & W>X
Y. Timothy ..	66		33			5% P.,
Z. Tumble down ..	70		49			Y>X

Visual symptoms.

In June 1955 it was clear from the colour of the leaves that all the trees under cover crops were suffering from nitrogen deficiency. This was confirmed by a response to urea foliar sprays, applied to similar trees outside the experimental area, and by the leaf analysis results (see Table VI). The drought during July and August 1955 accentuated this deficiency, thus depleting the nitrogen reserves for the following season.

Nitrogen deficiency was apparent early in 1956 but, as the season progressed, trees on the clover and tumble down plots improved in vigour and colour whereas trees on the timothy and rye grass plots became more deficient. This is illustrated clearly in Fig. 1 and Plate VI.

Leaf nutrient status.

From 1954 onwards leaf samples for chemical analysis were taken annually in August. Samples were collected from every tree and consisted of about twenty leaves-plus-petioles taken from the mid-third region of terminal shoots : the number of leaves per sample will be increased as the trees increase in size. So far analyses have been completed for total nitrogen, phosphorus and potassium, but it is intended to include magnesium and possibly trace elements later. The analytical results are given in Table VI, and the effects of cover cropping on the nitrogen and phosphorus status are illustrated in Figs. 1 and 2.

Worcester Pearmain.

Nitrogen. In the first season after seeding (1955), all cover crops reduced the leaf nitrogen concentration well below that of trees on arable plots, but there was no significant difference between covers. In 1956 differences between covers were highly significant : leaf nitrogen status was normal on clover plots, slightly deficient on tumble down plots and severely deficient on timothy and rye plots. There was no significant response to additional supplies of fertilizer nitrogen.

Phosphorus. Covers had a significant effect on leaf phosphorus in 1955, due mainly to relatively high values from trees on the tumble down plots, and still greater effects during 1956, the values from trees on clover plots being particularly high. There was no response to applications of phosphatic fertilizer.

A

B

C

D

Photos by permission of John L. Jones.

SHOWING THE EFFECT OF COVER CROPS (2ND SEASON) ON THE GROWTH OF COX'S ORANGE PIPPIN APPLE TREES.

A. Perennial rye grass, S. 23.
B. Timothy grass, S. 50.
C. Tumble down.
D. White clover, S. 184.

EFFECT OF COVER CROPS ON THE MEAN NUTRIENT CONCENTRATION OF MID-TERMINAL APPLE LEAVES.

(Results expressed as a percentage of dry matter).

Variety, sampling date and constituent	*W* White clover	*X* Perennial rye	*Y* Timothy	*Z* Tumble down	Sig. diff. 1%	Sig. diff. 5%	Comparisons	Arable
var. WORCESTER PEARMAIN								
19/8/54								
Total N	2·647	2·693	2·674	2·693	—	—	All plots under arable culture in 1954.	2·730
„ P	0·189	0·196	0·202	0·203	—	—		0·190
„ K	1·953	2·102	2·023	2·007	—	—		2·086
18/8/55								
Total N	1·783	1·757	1·721	1·766	—	—	N.S.	2·490
„ P	0·188	0·161	0·181	0·241	0·036	0·025	1%, Z>W,X,Y. 5%, W>X	0·209
„ K	2·342	2·498	2·259	2·460	—	—	N.S.	2·326
17/7/56								
Total N	2·209	1·529	1·703	2·048	0·119	0·083	1%, W>Z,Y>X	2·740
28/8/56								
Total N	2·216	1·375	1·554	1·891	0·101	0·071	1%, W>Z>Y>X	2·560
„ P	0·517	0·367	0·345	0·432	0·106	0·074	1%, W>X,Y. 5%, Z>Y	0·191
„ K	1·968	3·053	2·483	2·306	0·214	0·149	1%, X>Y,Z>W	1·916
var. COX'S ORANGE PIPPIN								
19/8/54								
Total N	2·492	2·483	2·525	2·547	—	—	All plots under arable culture in 1954.	2·470
„ P	0·212	0·214	0·231	0·216	—	—		0·204
„ K	1·934	2·012	2·083	1·941	—	—		1·875
18/8/55								
Total N	1·703	1·596	1·673	1·767	0·101	0·070	1%, Z>X. 5%, W>X,Y	2·400
„ P	0·236	0·172	0·229	0·289	0·044	0·031	1%, Z>W,Y>X	0·230
„ K	2·507	2·625	2·645	2·708	—	—	N.S.	2·141
17/7/56								
Total N	2·067	1·408	1·514	1·806	0·082	0·057	1%, W>Z>Y>X	2·455
28/8/56								
Total N	2·241	1·279	1·477	1·924	0·118	0·082	1%, W>Z>Y>X	2·464
„ P	0·504	0·353	0·389	0·421	0·069	0·048	1%, W>Z,Y,X	0·183
„ K	1·995	2·451	2·541	2·400	0·372	0·259	1%, X,Y,Z>W	1·696

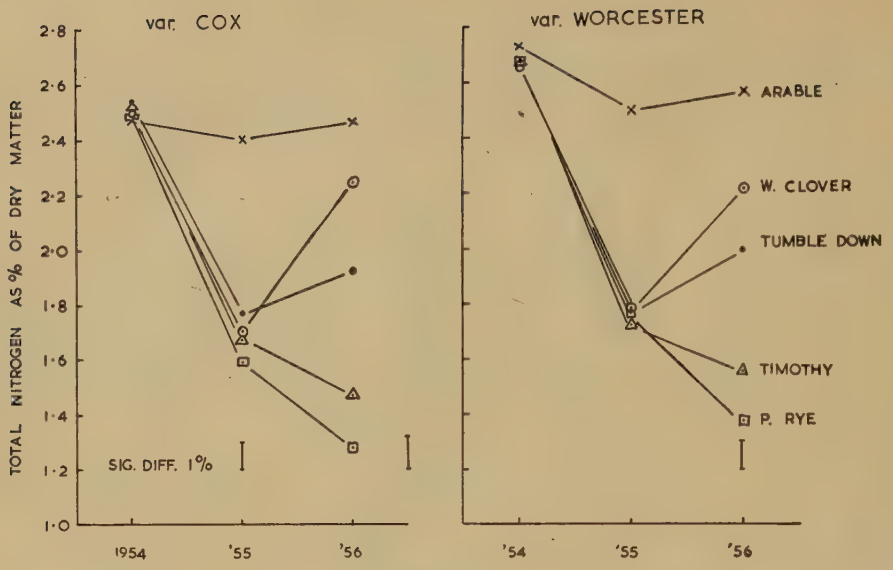

Fig. 1. The effect of cover crops on the nitrogen status of mid-terminal apple leaves. Sampled mid-August.

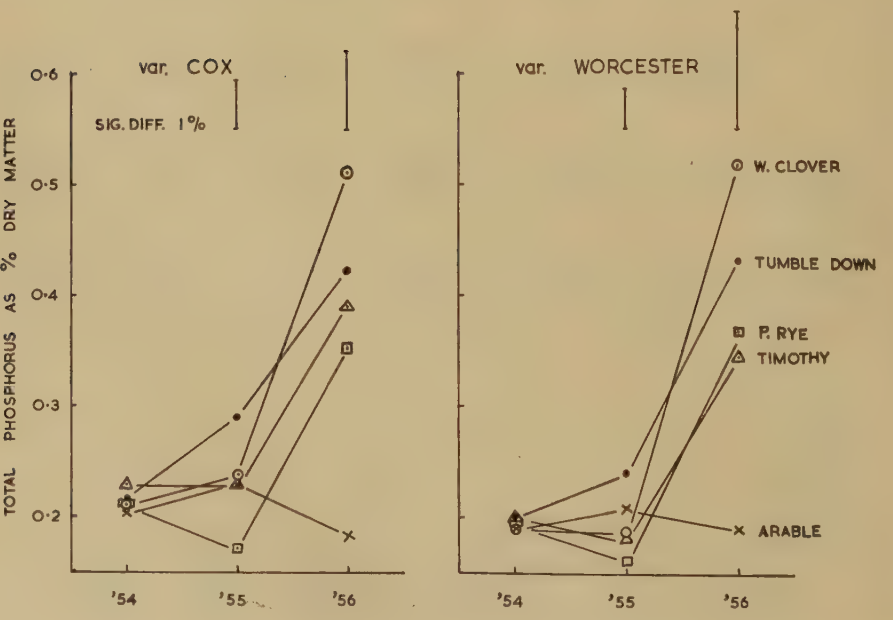

Fig. 2. The effect of cover crops on the phosphorus status of mid-terminal apple leaves. Sampled mid-August.

Potassium. Covers had no significant effect on leaf potassium during 1955, but differences during 1956 were highly significant ($P<0{\cdot}1\%$). The leaf potassium status of trees on grass plots was very high (luxury consumption level) and significantly greater than the level in leaves from trees on clover plots. There was no response to potassic fertilizer.

Cox's Orange Pippin.

Nitrogen. In 1955 all covers reduced considerably the leaf nitrogen status as compared with arable culture, the reduction being significantly less on tumble down plots. In 1956 differences between covers were highly significant ($P<0{\cdot}1\%$): leaf nitrogen status was normal in trees on clover plots; slightly deficient in trees on tumble down plots, and severely deficient in trees on timothy and rye grass plots. Contrary to the results with Worcester Pearmain trees, additional fertilizer nitrogen had a significant positive effect on the leaf nitrogen status of Cox trees.

Phosphorus. Cover crop effects were highly significant in both 1955 and 1956. In 1955 the leaf phosphorus values of trees on rye grass plots were significantly lower than those of trees on the other three treatments. In 1956 the values from all treatments increased considerably, the phosphorus status of leaves from trees on clover plots being exceptionally high, as in the case of Worcester Pearmain. There was no response to phosphatic fertilizer.

Potassium. Cover crops had no significant effect on leaf potassium in 1955, but effects in 1956 were highly significant, the values from trees on grass plots being considerably higher than those from trees on clover and arable plots. There was no response to potassic fertilizer.

Discussion.

At this stage in the experiment it is too early to draw any definite conclusions, but certain results merit comment. It is clear from Fig. 1 that in 1955 all the cover crops caused a considerable reduction in the leaf nitrogen status of both apple varieties, as compared with corresponding trees under arable cultivation, the reduction being least on Cox under "tumble down" grass treatment. In 1956 timothy and rye grass reduced still further the leaf nitrogen status, despite additional supplies of fertilizer nitrogen. The leaf nitrogen status of trees on the clover plots, however, improved considerably throughout 1956 and had reached a normal level by July-August, thus suggesting that the clover was making an effective contribution to the available soil nitrogen. Additional supplies of fertilizer nitrogen had no significant effect on the leaf nitrogen status of Worcester Pearmain trees, but they raised significantly the leaf nitrogen status of Cox's Orange Pippin trees. This relatively small response to fertilizer nitrogen confirms previous experience at Long Ashton (6), and points to the value of the urea foliar spray method for maintaining adequate levels of nitrogen during the first and second seasons after grassing down orchards.

The second interesting result is the effect of clover covers on the leaf phosphorus status of apple trees. Comparison between Figs. 1 and 2 indicates a general inverse relationship between leaf nitrogen and leaf phosphorus except in the trees on the clover plots. Although the nitrogen status of these trees is normal, the phosphorus level in the leaves is more than double

that of similar trees under arable culture. It would appear, therefore, that in addition to available nitrogen, available phosphorus was released under the clover crop during 1956. The leaf potassium levels, on the other hand, were lower in trees on clover plots than in trees on grass plots. These results are in keeping with the general inverse relationship between leaf potassium and leaf nitrogen concentrations.

There is little doubt that the striking effects illustrated in Plate VI were due partly to the dry period in 1955, which reduced the nitrogen reserves in the trees, partly to the early dry months in 1956, and also to the competitive effects of the grass covers for water and nitrogen.

Acknowledgments.

We wish to express our thanks to Mr. G. M. Clarke for the statistical analyses and for his advice on the experimental layout, to Mr. E. G. Bradfield and Mr. W. K. Hancock for the chemical analyses, and to Mr. J. L. Jones for the photographs of trees in Plate VI.

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MANURIAL EXPERIMENTS WITH FRUIT: I. THE EFFECT OF TREATMENTS ON SOIL FERTILITY AND ON THE GROWTH, YIELD AND LEAF NUTRIENT STATUS OF STRAWBERRY, var. ROYAL SOVEREIGN.

By C. BOULD and E. CATLOW.

In 1927 two long-term fertilizer plots, Nos. 12 and 17a, were laid down at Long Ashton in order to study the effect of treatments on soil fertility and on the growth and yield of horticultural crops. One of these plots, 17a, has been used for the present experiment. The test crop between 1927 and 1941 was black currant, for which potassium was the primary deficiency, but towards the end of the trial both nitrogen and phosphorus limited growth (3). From 1941 to 1953 vegetables, mainly potatoes and Brassicae, were used as test crops. This experiment, covering the period 1954 to 1956, was undertaken in order to investigate further the relationship between manurial treatments and soil fertility and their effects on the growth, yield and leaf nutrient status of strawberry, *var.* Royal Sovereign. A similar experiment on the second of the two long-term fertilizer plots, using strawberry *var.* Climax, has been described by Bould and Catlow (1).

Experimental.

Site and Soil.

The site is fairly level, low-lying and liable to be affected by late spring frosts. The soil is a fine sandy loam, calcareous from added lime, and belongs to Series No. 6 of the Research Station Soils (2). Chemical data relating to samples taken in March, 1954, are given in Table I. Data for samples taken in 1928 and 1937 have been given by Wallace (3).

Layout and Manurial Treatments.

The experimental area, measuring 60 yards × 42 yards, is divided into 18 plots, each 14 yards × 10 yards, arranged in three randomized blocks, each of 6 plots. The original planting scheme allowed for alternate double rows of the two varieties, Royal Sovereign and Climax, planted in rows 3′ apart, each plot containing 88 experimental plants per variety (buffered on all sides from adjoining plots). Unfortunately the variety Climax was severely affected by streak shortly after planting, and it was decided to remove this variety and to replant with Royal Sovereign in early autumn of the same year. The weather conditions at the time of replanting were very wet and the plants did not establish well. The following spring was cold and dry so that no crop was taken from these plants in 1955. The crop yields and leaf analysis data in this paper, therefore, refer only to the plants put out in the spring of 1954.

There are six manurial treatments, each in triplicate.

A. No manure ; *B.* Farmyard manure, 20 tons per acre at planting time only ; *C.* Complete fertilizer (NPK) ; *D.* PK ; *E.* NK ; *F.* NP.

Although the treatments have been the same since 1927, the fertilizer rates have varied according to the crop. The rates for strawberry were :—

N. 3 cwt. of ammonium sulphate (21% N) per acre.

P. 4 cwt. of superphosphate (19% P_2O_5) per acre.

K. 1 cwt. of potassium sulphate (48% K_2O) per acre.

From 1941 block II had received an annual dressing of Kieserite ($Mg\ SO_4.H_2O$) at 1 cwt. per acre : no magnesium was applied to blocks I and III, in which crops subsequently showed magnesium deficiency symptoms. To compensate for differences in soil magnesium the strawberry plants on blocks I and III were sprayed twice annually with a 2% solution of Epsom salts.

Prior to planting in the spring of 1954 the FYM, P, K and Mg fertilizers were broadcast over the plots and rotovated into the top 6″ of soil. A fortnight after planting N was applied as a side dressing. In 1955 to 1956 N, P, K and Mg fertilizers were applied as side dressings in early spring.

Management.

Normal cultivations included hand hoeing between the plants with shallow inter-row rotovations. Plants were de-runnered 2-3 times annually, de-blossomed in the first year, and maintained thereafter as single units. Approximately 5% of the spring-planted runners died and were replanted in the following September. No further replanting of casualties took place after this date.

Aphis was controlled with nicotine sprays, and captan was used at 2 lb./100 gal. for Botrytis control. In 1956 a general attack of mildew was only partially controlled by 1% lime sulphur.

Leaf Samples.

Composite samples of about 40 leaves-plus-petioles, one leaf from every other plant, were taken from each plot on four successive dates in 1955 : (i) three weeks prior to flowering ; (ii) at flowering ; (iii) at fruiting ; (iv) after fruit pick ; the latest fully formed leaf was selected at each sampling date. The samples were dried the same day at approximately 100°C., crushed, and sub-samples of about 10 g. retained for chemical analysis. These were analysed for total nitrogen, phosphorus, potassium and magnesium.

Experimental Records.

Data have been collected on soil fertility, plant vigour, plant losses, frost damage to blossom trusses, incidence of deficiency symptoms, yield and grade of fruit, and leaf nutrient status.

Results.

Soil Analysis.

Surface soil samples were taken on a plot basis in March, 1954 ; analytical data for these samples are given in Table I. Treatments had significant effects on all the constituents determined. At the 1% level of significance, F.Y.M. increased the organic carbon as compared with plots receiving fertilizers only ; omission of potassium reduced the level of exchangeable potassium ; and omission of phosphate decreased citric– and acetic acid–soluble phosphorus. Owing to the presence of free calcium carbonate soil pH was alkaline on all plots.

Plant Vigour.

Growth was estimated visually at intervals during the growing season by awarding marks from one to ten per plot according to vigour. The results are shown in Table II. Plants receiving F.Y.M. were outstanding, followed closely by those receiving NPK. There was little difference between plants on the PK and NK plots. Plants on the NP or no manure plots (K deficient) lacked vigour and became progressively poorer each season.

TABLE II.

VIGOUR MARKINGS FOR THE SEASONS 1954-56.

(Maximum total of marks for 3 plots = 30.)

Date	Treatments						Remarks
	A NIL	B FYM	C NPK	D PK	E NK	F NP	
1954							
June	13	28	24	19	17	19	
July	14	29	27	19	22	17	Slight K scorch on plots
August ..	16	28	26	21	23	14	A and F.
September ..	15	28	25	22	22	14	
1955							
May	15	28	27	22	22	14	Hail damage to foliage
June	14	27	27	21	24	14	1st pick } severe scorch
July	14	27	26	22	22	12	Last pick } on plots A and F
1956							
May	15	29	26	24	23	11	Ground frost damage
June	14	28	27	24	23	11	1st pick } severe scorch
July	13	26	26	23	22	10	Last pick } on plots A and F

TABLE I.

EFFECT OF MANURIAL TREATMENTS ON SOIL CONSTITUENTS, FEBRUARY, 1954.

(Mean values as percentage of air-dry soil).

Soil constituent	Treatments						Sig. diff.		Comparisons
	A NIL	B FYM	C NPK	D PK	E NK	F NP	** P=1%	* P=5%	
Organic carbon	1·97	2·58	2·00	2·14	2·28	2·04	0·32	0·23	**B>D,F,C,A. *B>E>F,C,A.
Exchangeable potassium (K)	0·006	0·012	0·009	0·012	0·012	0·008	0·003	0·002	**B,D,E>F,A ; C>A. *B,D,E>C.
Phosphate (P) sol. in 1% citric acid ..	0·015	0·036	0·030	0·029	0·017	0·030	0·009	0·007	**B,C,F,D>E,A. *B>C,F,D.
Phosphate (P) sol. in N/2 acetic acid ..	0·006	0·015	0·012	0·012	0·006	0·010	0·007	0·005	**B>A,E. *B>E ; D,C>A,E.
pH (soil : water = 1: 2·5)	7·8	7·8	7·8	7·6	7·9	7·9			

TABLE III.

EFFECT OF FROST DAMAGE ON STRAWBERRY BLOSSOMS 28/5/56.

(Mean values per plot).

	Treatments						Sig. diff.		Comparisons
	A NIL	B FYM	C NPK	D PK	E NK	F NP	** 1%	* 5%	
Total flower trusses (16 plants) ..	97	129	100	99	94	122	26	18	**B>A,C,D,E ; F>E. * F>A,C,D.
Total flower trusses sampled	30	39	31	32	31	37			
Total flowers counted from sampled trusses	308	466	318	365	328	366	115	81	**B>A,C,E. * B>D,F.
Flowers and fruits damaged	92	149	91	102	88	91			
% flowers and fruits damaged	29·8	31·9	28·5	27·9	26·9	24·7	N.S.	N.S.	

Plant Losses.

These were mainly attributable to potassium deficiency, although in 1956 green petal virus symptoms were evident ; several plants died due to this cause and others were probably affected by slight infection. No corrections were made except where virus was clearly responsible for death.

Frost Damage.

On May 19th and 20th, 1956, ground temperatures of 20°F were recorded. This caused severe damage to the first-formed flowers and considerably reduced the potential crop. A count was made on May 28th of flower trusses and damaged flowers, using a sub-sample of 16 plants per plot. The results are shown in Table III. It will be seen that about one third of the flowers were damaged by frost. Since these flowers would normally have produced the largest fruits the poor yields for 1956, shown in Table IV, can be attributed largely to frost damage.

Visual Deficiency Symptoms.

Slight manganese deficiency symptoms were recorded annually on all plots ; nitrogen deficiency was slight in plants on the PK plots, and the growth of plants on the NK plots was retarded in the first season. The major deficiency symptom was severe leaf scorch in plants on the NP and no-manure plots ; the symptoms first appeared about the time of fruit ripening. Potassium deficiency resulted in stunted growth and the loss of a considerable number of plants (see Table IV).

Crop Yields.

The crop yields given in Table IV are based on plant stand and were recorded in three grades ; (1) " SR " Ministry Grade ; (2) smaller sound fruit and (3) rotten and damaged fruits.

The highest yields of Grade I fruit and of total crop were obtained from F.Y.M. plots in both seasons. The omission of nitrogen and phosphorus had no significant effect on yield or grade of fruit, as compared with complete fertilizers. The omission of potassium significantly reduced the total crop yield, the percentage of Grade I fruit and fruit quality. The yields in the second cropping season were low, due to frost damage, but the relative order was similar to that in the first season.

Leaf Analyses.

The changes in leaf nutrient status due to treatments and time of sampling are shown in Fig. 1. Analytical data for leaf composition at the time of fruit ripening are given in Table V.

Nitrogen. The omission of fertilizer nitrogen had no significant effect on leaf nitrogen as determined at the first and second sampling dates, but differences became more marked and significant from the fruiting stage onwards. The values, however, were not unduly low and no significant effect on crop yield could be attributed to nitrogen. There was a steady decrease in percentage leaf nitrogen from flowering onwards.

TABLE IV.

EFFECT OF MANURIAL TREATMENTS ON CROP YIELDS—SPRING PLANTING.

(Mean values in tons per acre adjusted for plant stand).

	Treatments						Sig. diff.		Remarks
	A NIL	B FYM	C NPK	D PK	E NK	F NP	** 1%	* 5%	
1955									
Grade I	1·25	2·85	2·52	2·48	2·24	1·02	0·58	—	**B>E,A,F ; C,D,E>A,F.
Total crop	2·81	5·02	4·49	4·24	3·93	2·46	1·27	0·89	**B,C,D>A,F ; E>F. * B>E ; E>A.
Grade I in 1st week	0·93	1·36	1·31	1·44	1·25	0·79	0·33		**D,B,C,E>A,F.
Grade I as % of total crop ..	44·5	56·7	56·2	58·5	57·0	41·5	—	—	
Plant stand totals for yield estimates	256	250	257	250	251	258	—	—	Maximum stand = 264.
1956									
Grade I	0·46	1·70	1·37	1·10	1·45	0·22	0·42	0·30	**B>D,A,F ; C,E>A,F. * B>C,D ; E>D.
Total crop	1·34	2·84	2·52	2·10	2·50	0·77	0·73	0·51	**B>D,A,F ; C,D,E>A,F. * A>F.
Plant stand totals for yield estimates	250	249	247	241	247	251			Maximum stand = 264.
Total losses (1954-1956) attributed to treatments	23	5	3	2	2	59			

TABLE V.

EFFECT OF MANURIAL TREATMENTS ON THE LEAF NUTRIENT STATUS OF STRAWBERRY, *var.* ROYAL SOVEREIGN.

(Sampled 27/6/55. Mean values as percentage of dry matter).

Constituent	Treatments. A NIL	B FYM	C NPK	D PK	E NK	F NP	Sig. diff. ** 1%	* 5%	Comparisons
Total N	2·61	2·67	2·72	2·51	2·77	2·80	0·24	0·17	**F,E>D. * F>A; C>D.
„ P	0·241	0·254	0·235	0·225	0·249	0·240	—	—	N.S.
„ K	1·13	1·65	1·44	1·53	1·55	0·86	0·71	0·50	**B>F. * B>A; E,D,C>F.
„ Mg+	0·192	0·195	0·188	0·210	0·168	0·197	0·029	0·020	

+ Plants received two foliar sprays of 2% $MgSO_4.7H_2O$ prior to sampling.

Phosphorus. Treatments had no significant effect on the leaf phosphorus status except at the second sampling. Between the first and second sampling dates the plants suffered badly from hail and wind damage. This was followed by increased new leaf development, so that the leaves at the second sampling date were probably relatively younger than at the first sampling. This would account for their higher phosphorus status (see Fig. 1). Differences between treatments steadily decreased throughout the season.

Potassium. Omission of potassium from the fertilizer was reflected in a significantly lower leaf potassium at all sampling dates, the effect increasing with time. Severe leaf scorch developed about fruit ripening in plants on NP and no manure plots.

Magnesium. Except at the third sampling, treatments had no significant effect on leaf magnesium. The spray of Epsom salts given to the plants on Blocks I and III was apparently effective in countering the effect of the low content of magnesium in the soils of these blocks.

Discussion.

Differential manuring over a period of thirty years has produced significant differences in soil fertility. Plots receiving F.Y.M. had a higher organic carbon content than plots receiving inorganic fertilizers, but the level of organic matter on all plots was reasonably good for the texture of the soil. This would account for the relatively small effect of omitting fertilizer nitrogen on the growth of the strawberry, a crop which has a low nitrogen requirement. The levels of available phosphate were not unduly low on the NK plots, and were considerably higher than the values found on the plot (No. 12) used in the previous manurial experiments on strawberry (1). Omission of fertilizer phosphate reduced the available soil phosphate by approximately one half.

The exchangeable potassium on the NP and no manure plots was low and insufficient to supply the potassium requirements of the strawberry.

The highest yield of fruit was obtained from plots treated with farmyard manure. Reference to Fig. 1 shows that this treatment maintained adequate levels of nitrogen and phosphorus, and high levels of potassium, within the leaf throughout the period from early May to mid-July, thus confirming the previous findings with the variety Climax (1) that F.Y.M. applied at 20 tons per acre, prior to planting, is normally sufficient to maintain this crop for two to three years.

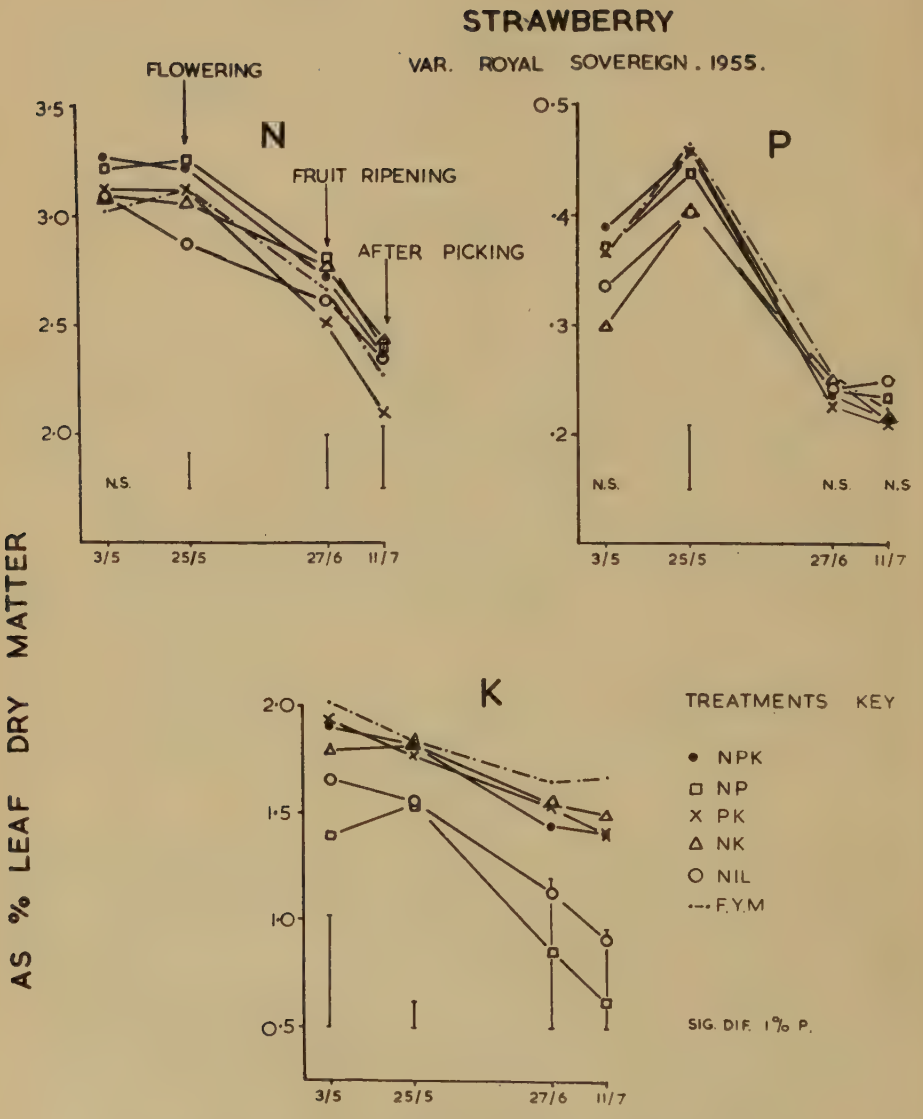

Fig. 1. The effects of manurial treatment and time of sampling on the nutrient status of strawberry leaves, *var.* Royal Sovereign, 1955.

Omission of nitrogen had no significant effect on yield of fruit, and in both seasons berries from these plots were outstanding for colour and firmness of flesh. Reference to Fig. 1 shows that the leaf nitrogen status of these plants was adequate, although it was lower at fruiting and after picking than that of plants receiving fertilizer nitrogen. Assuming adequacy of P and K the average leaf nitrogen values considered adequate for the variety Climax at flowering, fruit ripening and after fruit pick were respectively : 2.78, 2.33 and 1.93 per cent. The corresponding values for N-deficient plants were : 2.65, 2.10 and 1.69 per cent. dry matter respectively (1). The values for the PK (omit N) Royal Sovereign plants were 3.12, 2.51 and 2.09 per cent. dry matter. Since Royal Sovereign is a less vigorous variety than healthy Climax it can probably tolerate a little more nitrogen and a higher leaf nitrogen status without adverse effects on the quality of its fruit or on the incidence of Botrytis.

Apart from some retardation in growth in the season of planting, omission of fertilizer phosphate had no significant effect on growth and crop yield. Furthermore the leaf phosphorus status of plants on the NK (omit P) plots was normal, and at fruit ripening and after fruit pick it was not significantly lower than in plants receiving fertilizer phosphate. These results are in keeping with those found for the variety Climax (1).

The yield and quality of fruit on the NP (omit K) plots was poor, and the berries were small, dull and insipid. The average leaf potassium concentrations of normal plants at flowering, fruit ripening and after fruit pick were : 1.95, 1.93 and 1.54 per cent., whereas the corresponding values for potassium deficient plants were 1.55, 0.99 and 0.77 per cent. dry matter respectively.

These results are in keeping with previous experience with strawberry. They emphasize the importance of adequate supplies of potassium for high yields of good quality fruit, the relatively low requirement for fertilizer nitrogen, and the apparent lack of response to fertilizer phosphate, except in the early stages after planting : once plants are established they appear able to mobilize sufficient phosphorus from soils low in available phosphate. The results also confirm the value of leaf analyses when samples are drawn by a standard procedure and are compared only with other samples taken at comparable dates. Rapid changes in nutrient concentration take place between flowering and fruit maturity and a normal leaf value for N, P and K determined at fruit maturity would appear as severely deficient if compared with normal values determined at the flowering stage.

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STUDIES ON THE NATURAL PROTECTIVE COVERING OF PLANTS: I. PLANT WAX IN RELATION TO RESISTANCE TO INFECTION BY FUNGI.

By J. T. MARTIN.

The natural protective covering of many plants consists of a surface deposit of waxy material associated with the cutin of the epidermal cells. The leaves and fruits of different species or varieties vary greatly in the degree of waxiness shown. Schieferstein and Loomis (1) have published lists of waxy and non-waxy plants ; among those given as non-wax bearing they have cited potato, tomato, tobacco, convolvulus and plantain. The surface wax appeared to be deposited essentially during or shortly after the period of leaf expansion. Regeneration of wax was demonstrated on growing cabbage leaves, but older leaves showed no further wax extrusion. Jordan and Chibnall (1938) found that wax was synthesized continually throughout the life of the runner bean plant in all organs except the roots. Schieferstein and Loomis found no evidence of wax canals through the cuticle, although these have been reported by other workers. Suggestions have been made that the wax is secreted in liquid or paste form through the apparently intact cuticle and then hardens or partially crystallizes on the surface. Conrad and Neely (1943) showed that a hereditary factor controlled the quantity of cotton lint wax produced, while other workers have indicated that plant maturity and climatic environment may affect the quantity and quality of wax exudate. Kutz (1950) in an examination of thirteen species of plant, found that the wax and non-wax fractions of the protective covering varied with the species of plant, but that the yield of the wax fraction was proportional to the thickness of the cuticle. Wax deposits have been considered to play an important rôle in the water economy of plants, but Schieferstein and Loomis found no direct correlation between the amount of surface wax present and xeromorphic adaptation.

The waxy covering in relation to wetting, insecticide deposits and phytotoxicity.

The protective layer confers on the plant the property of water repellency which needs to be overcome, by the use of wetting agents, if the efficient deposition of spray chemicals is to be achieved. The leaves of some plants, e.g. cabbage, onion and blackcurrant, are difficult to wet ; those of others, e.g. the potato and apple, are wetted with comparative ease. Differences in the retention of spray fluids are found between leaves of different ages, and between the upper and lower surfaces of a single leaf. Mueller *et al* (1954) have observed that the concentration of wetting agent required to give complete wetting of a plant surface decreases with the weathering of the surface wax. The wax superimposed on the cutin clearly forms the surface with which we are concerned in spray application problems.

Other considerations have emphasized the importance of the study of plant waxes. Fat-soluble insecticides such as DDT deposited on the plant may become dissolved in the wax layer and rendered less available to the insect to be controlled. Alternatively, a solution of the insecticide in a thin film

of wax may be more toxic to the pest than crystals deposited on the wax surface. At present we know little of the behaviour of deposits of insecticides such as DDT on plant surfaces, and work on this is in progress. Furthermore, the extent and nature of the waxy covering may influence the susceptibility of a plant to damage by spray materials.

The chemical basis of resistance to disease.

Another subject of considerable interest is the possible part that components of the wax may play in determining the resistance or susceptibility of a plant to fungus attack. Many workers have suggested that the natural resistance of plants to disease may have a chemical basis. Zschokke, as early as 1897, considered that any resistance of apple fruits to infection was due to chemical substances and not to mechanical protection afforded by the cuticle. Wiltshire in 1915 (2), working at Long Ashton, reported a correlation between varietal resistance to apple scab and the reduction of conidial germination in expressed saps ; the age of the foliage and fruits affected the inhibitory power of the liquids. Miss Johnstone (3) in 1931, also at Long Ashton, thought that barriers of an anatomical nature were of subsidiary importance in determining varietal resistance to apple scab, and showed that the leaves of resistant varieties tended to yield a more toxic liquid than those of susceptible varieties.

Earlier, Brown (4) had found evidence of water-soluble compounds exuded from leaves that were stimulatory, and in some cases inhibitory, to *Botrytis cinerea*. Newton and Anderson (1929) and Kargopolova (1936), have associated the presence of phenolic compounds in wheat plants with their resistance to rust (*Puccinia triticina*) while Turner (1956) has shown that the sap of seedling oat leaves contains an inhibitor of *Ophiobolus graminis*. Walker and his co-workers (1930) detected protocatechuic acid and catechol in the scales of onion varieties resistant to smudge, but not in those of susceptible varieties. Irving and his associates (1946) found that tomatin, present in tomato plants, possessed fungistatic activity against *Fusarium* causing wilt diseases in tomato, pea and cabbage. Gilliver (5), in an examination of 1,915 plants, showed that 23 per cent. gave macerates that inhibited the germination of conidia of *Venturia inaequalis* ; with some, the natural inhibitors were localized in the leaves, but with others, there was more general distribution throughout the plants. Chlorogenic acid, a naturally-occurring depside, has recently been associated with plant resistance to disease. Johnson and Schaal, in 1952, found it to be present in the region of the periderm in all potato varieties resistant to scab, the level of concentration being related to the degree of resistance of the variety. Kirkham at East Malling has shown (6) that the injection into apple shoots of the aromatic fraction of Cox leaf extract reduced infection by scab. Further studies by Kirkham and Flood (7) indicated that, of the plant phenols, compounds of the chlorogenic acid type probably played an important part in a natural defensive mechanism. Cruickshank and Swain (1956) also have investigated chlorogenic acid and other phenolics in oil-flax varieties in relation to resistance to the rust *Melampsora lini*, while Valle (1957) has reported anti-fungal factors, associated with chlorogenic acid, in potato leaves. Buxton (1957) has shown that pea root exudates are active against *Fusarium oxysporum*.

Recently, Topps and Wain (8) found that the water washings of the intact leaves of some species of plant contained small quantities of compounds

possessing fungistatic properties and suggested that the exudations may represent a means of defence. Spencer, Topps and Wain (9) have also shown that segments of the stem and primary root of the broad bean plant exude an antifungal agent, phenolic in character, and indicate that this may be produced in the tissues in response to a wounding stimulus. The presence in plants of antibacterial substances has been shown by a number of workers. It is of interest to note that Koidsumi (1957) has recently described the antifungal action of cuticular lipoids in insects, while Mackie and Misra (1956) have shown that a fraction of *Anona* leaf wax possesses anthelmintic properties.

The investigations referred to above have been concerned with fungistatic compounds present in plant tissues, usually tested as macerates. We have confined our attention to compounds contained in the natural waxy covering of plants, since it is this surface upon which fungus spores alight and which may provide the first barrier to the setting-up of an infection. The plant materials to be examined were selected on the basis of their known resistance or susceptibility to a particular disease, with a view to obtaining information on the possible rôle of wax components in influencing varietal response to attack.

The chemical nature of plant wax.

Power and Chesnut (1920) examined the odorous constituents of apples and detected the emanation of acetaldehyde from ripe fruits. Sando (1923) reported the presence of triacontane, heptacosanol and a compound he called malol in apple wax. In 1931, Sando confirmed the report by Van der Haar that malol was identical with ursolic acid, previously isolated from the leaves of the bear-berry, and with prunol from the leaves of the wild black cherry. Sando also described an oily fraction of apple wax which he determined by subtracting the content of malol, found by titration, from the total ether extract. Markley and Sando (1931) found that the oily fraction increased at a greater rate than the malol during growth and storage. The malol was water-repellent and affected the wetting of the fruit.

From about 1930 onwards Chibnall in London and Piper at Bristol, with their associates, collaborated in extensive investigations on the constituents of plant waxes, including the synthesis and characterization of reference compounds for identification purposes, and on the formation and metabolism of plant and insect waxes. These workers in 1931 identified *n*-nonacosane, *n*-heptacosane, 10-nonacosanol, *n*-hexacosanol, *n*-octacosanol and *n*-triacontanol as constituents of the wax obtained from dried apple peel. They showed that the triacontane and heptacosanol of Sando were in fact *n*-nonacosane and 10-nonacosanol respectively, and this was confirmed by Markley, Hendricks and Sando. From whole apples, washed with ether, Gane in 1931 obtained an oil in addition to wax and ursolic acid, and showed that the oil consisted mainly of unsaturated esters. More recently, Huelin and Gallop (1951) have followed the changes in the oil, wax, ursolic acid and cutin fractions of apple fruit wax during storage ; the maximum increase was shown by the oil fraction. Davenport (1956) has shown that the acids of the oil fraction are chiefly stearic and arachidic.

Other plant waxes have been examined, and reports of the identification of constituents include the following : di-*n*-tetradecyl ketone from cabbage (Channon and Chibnall, 1929) : *n*-octacosanol, fatty acids and paraffins from

wheat, and *n*-hexacosanol and a small quantity of *n*-tetracosanol from cocksfoot and perennial rye-grass (Pollard, Chibnall and Piper, 1933) : paraffins from C_{21} to C_{35} from rose petal wax (Chibnall, El Mangouri and Piper, 1954) : *n*-triacontanol, *n*-octacosanol and C_{29} to C_{31} paraffins from alfalfa (Blair, Mitchell and Silker, 1953) : *n*-paraffins between C_{24} and C_{36} from pyrethrum (Wanless *et al*, 1955): fatty acids, primary alcohols, palmitone and sesquiterpene oils from *Anona* (Mackie and Misra, 1957), and fatty acids, ursolic acid and d-glucosidylsitosterol from the cherry *Prunus avium* (Markley and Sando, 1937). Arnold and Hsia (1957) have described the extraction of ursolic acid from cranberry skins ; this compound has been used commercially as an emulsifying agent in pharmaceutical preparations.

Some doubt exists concerning the definition of " wax ". Blair, Mackie and Chibnall and their co-workers obtained their material by precipitation with acetone from an extract of plant tissue. This procedure gives the true wax contained in the protective layer of the plant, but other constituents remain in solution in the acetone. Other workers have referred to the acetone insoluble and soluble portions as " hard " and " soft " wax, or as " wax " and " non-wax " fractions. Huelin and Gallop obtained " wax " and " oil " as the acetone-insoluble and soluble fractions of a petroleum extract, and obtained the ursolic acid by further extraction with ether.

In our work, we have regarded surface wax as the material removable by washing the intact plant tissue with ether at room temperature. The main steps in the fractionation used consisted of washing the ether extract with dilute alkali to remove acidic material, steam distillation of the residue to separate volatile constituents, followed by acetone precipitation from an ether solution to distinguish between the true wax and oil.

Experimental.

(a) *Chemical tests.*

The plant materials selected for examination, which so far as could be ascertained were free from spray residues, and the reasons for their choice, were as follows :—

Leaves of Worcester apple : comparatively resistant to mildew.

Leaves of Cox apple : susceptible to mildew.

Fruits of Crawley Beauty and Winston apple : resistant to *Gloeosporium* in storage.

Fruits of Allington apple : susceptible to *Gloeosporium* in storage.

The intact leaves or fruits were washed, in beakers, with successive portions of ether at room temperature, or were percolated with ether in a large soxhlet-type extractor. The ether solution of wax was washed four times with 1 per cent. potassium hydroxide solution and the acidic material was recovered in ether solution. After washing free from alkali, the solvent was removed from the residue, steam distillation was carried out, and the volatile fraction separated with ether. The material remaining after distillation was taken up in ether, an excess of acetone was added, and the precipitated wax was separated after refrigeration. The oil was recovered from the acetone filtrate. The fractions, in dried ether solution, were made up to volume and aliquots taken to determine their weights. Aliquots of the initial solutions were sometimes reserved for the determination of total extract. In some

cases, additional materials, separating from the original solution (" ether insoluble ") or from the potash layer (" insoluble acids ") were obtained.

The proportions of the different fractions found, expressed as percentages of the total quantity of material recovered, are given in Table I.

TABLE I.

FRACTIONATION OF LEAF AND FRUIT WAXES OBTAINED BY ETHER EXTRACTION.

Material	Percentage of total wax					
	Ether insol.	Insol. acids	Acids	Volatile	True wax	Oil
Worcester, young leaves ..	nil	nil	55·3	3·9	7·9	32·9
Worcester, old leaves ..	37·2	nil	52·7	0·4	2·6	7·1
Cox, young leaves	nil	nil	54·9	3·7	11·0	30·5
Cox, old leaves	20·7	nil	73·6	0·1	1·3	4·4
Crawley Beauty fruits ..	nil	25·4	4·5	5·3	15·1	49·7
Winston fruits	nil	nil	46·4	2·2	25·4	26·0
Allington fruits	nil	19·5	26·1	4·0	22·4	27·9

After ether washing, the Winston and Allington apples were thinly peeled, the peel was air-dried at room temperature, and percolated with slightly warm acetone. Wax separating from the refrigerated acetone solution was filtered off, the residue from the filtrate was taken up in ether, and acid, volatile and oil fractions were determined as before. The results, again expressed as percentages of the total material recovered, are given in Table II.

TABLE II.

FRACTIONATION OF FRUIT WAXES OBTAINED BY ACETONE, AFTER ETHER, EXTRACTION.

Material	Percentage of total wax				
	Insol. acids	Acids	Volatile	True wax	Oil
Winston fruits	nil	45·6	0·4	38·8	15·2
Allington fruits	nil	25·2	1·6	61·3	11·9

The Worcester and Cox leaf acid fractions, which showed biological activity (see p. 99) were further examined. The Worcester fraction was subjected to paper chromatography using a benzyl alcohol-isopropyl alcohol-tertiary butyl alcohol-formic acid-water mixture. The main acidic spot ($R_F = 0·82$) showed some fluorescence which was rather stronger with ammonia. Positive reactions were obtained with the following reagents : ferric chloride (reddish purple, brown on exposure to ammonia), ferric chloride-potassium ferricyanide (strong blue colour), alkaline potassium permanganate (yellow colour), and diazotised *p*-nitraniline (strong reaction, orange). Ammoniacal silver nitrate was reduced. The material was phenolic. Similar reactions were obtained with the Cox leaf acid fraction.

The Cox acid extract was then fractionally eluted from a silica gel column with chloroform and chloroform-tertiary butyl alcohol mixtures. Traces of fluorescent materials appeared in the early fractions. Two main components

were obtained. The first gave a bright blue fluorescence with ammonia, reduced silver nitrate weakly, was strongly acidic, and gave no reaction with diazotised *p*-nitraniline. The solid recovered from the eluate melted at 123-127°C. The second component was acidic, reacted strongly with ferric chloride and with diazotised *p*-nitraniline, and reduced silver nitrate.

Other tests showed that the " insoluble acid " material which was obtained in crystalline form from the Allington fruit was non-phenolic in nature.

(b) *Fungitoxicity tests.*

The fractions obtained were examined for their ability to inhibit the germination of spores of *Botrytis fabae*, *Gloeosporium perennans* and *Podosphuera leucotricha*. The tests with *Botrytis* and *Gloeosporium* were carried out on cavity slides, a drop of spore suspension being confined on a thin layer of the wax fraction. With apple mildew, leaf tests were used. Leaves of mildew-susceptible apple were lightly sprayed with ether solutions of the materials and, after spore inoculation and incubation, the spores were recovered from the leaves, by the method of Bennett and Furmidge (10), for microscopic examination.

The tests are regarded as exploratory at this stage, but interesting effects were observed. The materials showing activities against the fungi named were as follows :—

Botrytis : Worcester and Cox leaf acid fractions ; Crawley Beauty fruit wax and volatile fractions.

Gloeosporium : Worcester leaf wax fraction ; Worcester and Cox leaf volatile fractions ; Crawley Beauty fruit wax and volatile fractions.

Podosphaera : Worcester and Cox leaf acid fractions ; Worcester leaf wax and volatile fractions.

Discussion.

The analytical data have provided interesting information on the levels of surface waxy deposits on apple foliage and fruits. Young Worcester leaves showed 0·52 per cent. of wax-like material (on fresh weight), equivalent to 51 μg/sq. cm. of leaf surface. The surface waxy content of Crawley Beauty apples was 0·11 per cent., of Winston 0·12 per cent. and of Allington 0·10 per cent.

The recoveries of the waxy materials in the fractionations usually comprised 75-80 per cent. of those present in the original extracts. Losses may have occurred by the incomplete recovery of the acidic and volatile fractions and by discarding materials that separated at interfaces during the extractions. The values for the " ether-insoluble " and " insoluble acid " fractions have little significance since the amounts of plant material and reagents used varied widely ; when material separated from the original ether extracts, low values for the volatile, true wax and oil fractions resulted.

Acetone extraction of the peel of apples, taken after ether washing of the whole fruits, recovered additional amounts of waxy material, rich in acids and true wax, which may have been more closely associated with the cuticular layer.

The most striking result is the high proportion of acidic material occurring in the leaf and fruit surface coverings. Chromatographic tests have shown that the acid fractions of Worcester and Cox leaves, which show properties very

similar to those of the antifungal compound detected by Spencer, Topps and Wain (*loc. cit.*), are essentially mixtures of a phenolic compound and an acidic, non-phenolic substance. The Worcester and Cox leaf fractions differed in the relative amounts of these two components, the phenolic compound predominating.

The biological results show that some of the fractions of the waxy surface layer possess fungistatic properties. This fact, in conjunction with the high proportions in which they occur in the waxy deposits, may enable them to exert a detrimental effect upon potentially infective fungus spores. Once the surface protective barrier has been overcome, the invading mycelium may also encounter natural inhibitors, within the tissues, which prevent the establishment of a lesion. Earlier workers, using macerates, have obtained an overall picture of the chemical defensive mechanism of leaves. In our work we have attempted to examine separately any effect of the natural waxy covering, but are left in doubt as to the site of formation of its acidic fraction. Is this an integral part of the waxy layer, or is it produced within the leaves, exuding to the surface and mixing with the waxy covering? The acidic material shows some solubility in water; it is possible that water films may dissolve the acids to give media toxic to fungus spores present on the leaves. Similar substances may account for the fungistatic effects of the water washings of leaves found by other workers. Reduction of the acidic fraction in the waxy layer by weathering may also be expected unless it is constantly regenerated.

The investigations reported have produced little definite information on the chemical factors underlying varietal differences in resistance to disease, but interesting pointers have been obtained. Work on this subject, on the changes in the amount and composition of waxy deposits with age and nutritional status, and on the water-repellency of the wax fractions, is proceeding.

Summary.

(1) The fractionation of the surface waxy layer of apple foliage and fruits into acidic, volatile, wax and oil components is described.

(2) Fungitoxicity tests indicate that some of these components may play a part in influencing the resistance of apple leaves and fruits to surface infection by fungi.

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THE FUNGISTATIC PROPERTIES OF COAL TAR CONSTITUENTS.

By G. V. COLES, J. T. MARTIN and R. J. W. BYRDE.

Accounts have been given in earlier reports (1,2) of investigations of coal tar preparations used in Malaya and elsewhere for the control of the mouldy-rot disease of the rubber tree caused by *Ceratostomella fimbriata* (Ell. & Halst.) Elliot. Tests for fungistatic activity were carried out on proprietary materials and their component fractions, using the fungus received from Malaya and cultured at Long Ashton. The tar acid fractions showed greater activities than the neutral or basic components, and the maximum effect was associated with the acids included in an approximate boiling range of 220-250°C. The work was later extended to an examination of the effects upon the mycelium of the mouldy-rot fungus of individual compounds known to occur in coal tar distillates. This note is a summary of the findings, which will be fully published elsewhere.

The compounds used were pure samples kindly supplied by the D.S.I.R. Chemical Research Laboratory, the Coal Tar Research Association and Coalite and Chemical Products Ltd., or were manufacturers' chemicals of good quality. Each compound was incorporated in emulsion form, at 100 p.p.m., in a peptone-agar medium which was then inoculated with a small disc of the fungus mycelium. The fungistatic activity of the compound was assessed from the percentage inhibition of the radial growth of the fungus, at 25°C, over the 2 to 4 day period after the commencement of the test (1). In each batch of trials 4-phenyl phenol, at 25 p.p.m., was included as a standard fungicide; the percentage inhibitions of growth recorded for the standards throughout the tests varied between 29·5 and 40·5.

As a class, the tar acids showed a much greater level of activity than the neutral tar constituents. An approximate and arbitrary classification of effectiveness may be made by listing the compounds showing high activity (percentage inhibition of growth 75 or more); those showing moderate activity (percentage inhibition 35 to 75); and those of low activity (percentage inhibition below 35), as follows:

High activity:

Acidic compounds: 3,5-xylenol*, 4-ethyl phenol*, 3-methyl-4-ethyl phenol*, 3-methyl-5-ethyl phenol, 3-methyl-6-ethyl phenol, 4-n-propyl phenol*, 3,5-diethyl phenol, 4-n-butyl phenol, 4-indanol*, 2-naphthol*, 2-phenyl phenol*, hydroquinone, and 2, 2′-dihydroxy diphenyl.

Neutral compounds: none.

Basic compounds: skatole*.

Moderate activity:

Acidic compounds: *o*-cresol*, *m*-cresol, *p*-cresol*, 2,3-xylenol*, 2,4-xylenol*, 2,5-xylenol*, 2,6-xylenol*, 3,4-xylenol*, 2-methyl-4-ethyl phenol*, 2-methyl-5-ethyl phenol*, 2,3,5-trimethyl phenol*, 3,4,5-trimethyl phenol*, 5-indanol*, 5-methyl-4-indanol*, phenanthrol-2*, catechol*, 3-methyl catechol* and 4-methyl catechol*.

Neutral compounds: acenaphthene, diphenyl*, diphenylene oxide.

Basic compounds: acridine.

* Significantly greater activity at $P = 0{\cdot}05$ than compounds in the next lower group.

Low activity :

Acidic compounds : phenol, 1-naphthol and resorcinol.

Neutral compounds : naphthalene, 1,6-dimethyl naphthalene, 2,3-dimethyl naphthalene, 2,6-dimethyl naphthalene, 2,7-dimethyl naphthalene, 4,4′-dimethyl diphenyl, fluorene, anthracene, 1,2-benzfluorene, 2,3-benzfluorene, benzoindane, phenanthrene, methylene phenanthrene, pyrene, fluoranthene, diphenylene sulphide, 1,9-benzoxanthene, brazane and thionaphthene.

Basic compounds : carbazole.

The results confirm the high efficiencies of the tar acids found in earlier work. The activities of the compounds relate to the one species of fungus used, and different effects may result from work with other fungi. The limitations in the solubility of some of the compounds may also have influenced their activities.

Most of the work on tar constituents as fungicidal agents carried out by other investigators has been concerned with wood preservation. In investigations on fruit pathogens, acenaphthene, diphenyl, naphthalene, fluorene and phenanthrene have been found to reduce hyphal growth of *Monilinia fructicola*, but to have no effect on conidial germination (3). The fungitoxicities of acridine, carbazole, diphenyl sulphide and 2- and 4-phenyl phenol have been investigated (4,5), and fluorene, acridine and carbazole have been examined for chemotherapeutic activity against the *Fusarium* wilt of tomato (6). Diphenyl has been used in protectant citrus fruit wrappings, and the value of 2-phenyl phenol in protecting stored mangoes has recently received attention (7).

The property usually associated with tar acids is phytotoxicity. The content of phenols in the ovicidal tar oil winter washes is kept within a prescribed limit because of the risk of damage, and tar acids have been used for potato haulm destruction. In the treatment of the mouldy-rot disease, no injury to the rubber tree results from the application of tar preparations containing 1 per cent. or more of mixed phenols.

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SPRAYING EXPERIMENTS AGAINST APPLE SCAB AT LONG ASHTON, 1956.

By R. J. W. BYRDE, G. M. CLARKE and C. W. HARPER.

This report describes the final year of a three-year trial designed to assess the relative performances of captan and lime sulphur as post-blossom fungicides on the apple variety Cox's Orange Pippin. In the two previous seasons (1,2), the level of apple scab infection (caused by *Venturia inaequalis* (Cooke) Wint.) was very low on plots receiving either treatment. There was a significantly higher incidence of apple mildew (caused by *Podosphaera leucotricha* (Ell. and Everh.) Salm.) on the shoots of the 1954 season's growth on plots receiving captan, and in autumn 1955 only those plots that had received lime sulphur throughout in both seasons were substantially free from the disease. The amount of overwintering inoculum of the mildew fungus nevertheless appeared very low in both treatments, and its economic importance was considered to be negligible. The substitution of captan for lime sulphur in the post-blossom sprays in 1954 led to a significant reduction in fruit russet, and in 1955 there were indications of an increase in crop weight on the captan-treated plots.

The value of captan in other parts of the country has recently been discussed by Bush (3), who reported that apple mildew caused serious damage in part of an orchard in East Anglia where captan was substituted for lime sulphur : in a Hampshire orchard, however, a markedly greater crop was recorded in 1955 on the captan-treated area, without serious mildew attack, a result similar to that at Long Ashton.

Experimental.

Fungicides. The spray materials were formulated as follows :—

Lime sulphur, as the commercial concentrate diluted to 1½% (pre-blossom) or to ¾% (post-blossom).

Captan (N-trichloromethylthio-tetrahydrophthalimide), as an aqueous suspension of a commercial wettable powder (50% captan) used at 1½ lb. per 100 gal.

The sprays were applied at approx. 240 gal./acre by a mobile spraying machine using two twin-nozzle hand-directed brooms with 4/64 in. disc apertures and short-range swirl plates. The output of each broom was approx. 3 gal./min. Details of the spray applications during 1956 are given in Table I. The " pink bud " spray application was omitted, owing to very rapid bud development during a warm spell in early May ; the first post-blossom application was therefore advanced to 70% petal fall. The extra application of DDT in early July was included because of a noticeable increase in codlin moth during the warm dry summer of 1955, which, it was feared, might lead to a serious attack in 1956.

Layout. The general layout of the site was described in (1). In 1956, the treatments were again re-allocated to the plots, as indicated in Table II. As before, each experimental plot consisted of the full length of four rows, extending over three planting systems, which were recorded separately. These planting systems are referred to as IIA (M. II rootstock without " fillers "), IIB (M. II rootstock with " fillers ") and IXB (M. IX rootstock, used as " fillers "). All records were taken on the variety Cox's Orange Pippin.

TABLE I.

SPRAY APPLICATIONS DURING 1956 : QUANTITIES PER 100 GAL. WASH.

Date	Stage	Fungicide	Insecticide or Acaricide	Wetting Agent
May 3	Green cluster	Lime sulphur 1½ gal.	DDT (a) 4 oz. *gamma* BHC (a) 1 oz.	Dioctyl sodium sulphosuccinate (b) 3 oz.
May 17	70% Petal fall	(i) Lime sulphur ¾ gal. *or* (ii) Captan (50%) 1½ lb.	*gamma* BHC (a) 2 oz.	—
June 8	Fruitlet	(i) Lime sulphur ¾ gal. *or* (ii) Captan (50%) 1½ lb.	—	—
June 25 and July 9	"Codlin"	As above	DDT (a) 8 oz. Chlorbenside (a) 3¼ oz.	Dioctyl sodium sulphosuccinate (b) 1 oz.

(a) As benzene emulsion. (b) In acetone solution.
Magnesium sulphate (20 lb. per 100 gal.) was applied over the whole orchard on June 6 ; 1-naphthalene acetic acid (10 p.p.m.) was applied throughout on Sep. 6-7. Wetting agent was incorporated in both sprays.

Methods of assessment. These were identical with those used in 1955 (2).

Notes on weather.

The growing season of 1956 was characterized by low rainfall in late spring, followed by an exceptionally wet August. The rainfall figures (in.) for each month are shown below, with average figures (1914-53) in brackets :—

April, 1.92 (2.33) ; May, 0.50 (2.59) ; June, 2.78 (2.11) ;
July, 4.26 (3.16) ; August, 7.99 (3.65) ; September, 3.55 (3.15).
Total, 21.00 (16.99). Excess, 23.6%.

Taking the summer as a whole, sunshine and temperature were substantially below normal. The dry period in April and May prevented an early scab infection and the disease never became severe, even on unsprayed trees of Cox's Orange Pippin elsewhere in the Long Ashton plantations.

Results.

On foliage and blossom trusses.

Apple mildew was assessed on blossom trusses on May 22, 1956. 90 trusses were examined per treatment in each planting system. The numbers of infected trusses for systems IIA, IIB and IXB respectively were 0, 0, 0 for the plots sprayed in 1955 with lime sulphur and 0, 0, 1 for those sprayed in 1955 with captan. As these results were obtained 5 days after the application of differential spray treatments in 1956 they reflect only the residual effects of the 1955 treatments.

A further assessment of apple mildew was carried out on shoots of the current season's growth on August 28, with the results given in Table II. These show that treatment with post-blossom lime sulphur in 1956 was followed by a marked reduction in the level of mildew by comparison with plots receiving post-blossom captan. There was no indication of any further residual effect of the 1955 treatments except on the plots that had received lime sulphur at all stages in each of the three seasons ; here the incidence of the disease was much lower than on any other plots.

TABLE II.

PERCENTAGE SHOOTS OF CURRENT SEASON'S GROWTH SHOWING MILDEW INFECTION, AUGUST 28, 1956.

Block	Post-blossom fungicide+			Planting system		
	1954	1955	1956	IIA	IIB	IXB
1	LS	LS	LS	35	10	10
	C	C	C	82	65	82
2	LS	C	C	77	72	78
	C	LS	LS	40	32	28
3	C	LS	C	80	87	82
	LS	C	LS	52	33	27
Overall means for 1956 treatments			LS	42 } *	25 } **	22 } *
			C	80 }	75 }	81 }

+ LS = Lime sulphur ; C = Captan.
Plots are listed down the table from north to south.
Differ significantly at the 5% level (*) or the 1% level (**).

On fruit.

The fruit of the variety Cox's Orange Pippin was picked from September 26 to October 3. The total fruit from each recorded plot was again bulked in three batches corresponding to the three planting systems, and random samples of about sixty fruits were taken from orchard boxes by the method of Pearce (4).

Scab was assessed on these samples on October 4 ; the results are summarized in Table III. As in previous years, no statistical analysis was carried out, owing to the very low incidence of the disease.

TABLE III.

PERCENTAGE FRUIT AREA SCABBED ON SAMPLES, OCTOBER 4, 1956.

1956 post-blossom fungicide	Planting system		
	IIA	IIB	IXB
Lime sulphur	0.05	0.03	0.00
Captan	0.00	0.01	0.00

Fruit russet was also estimated on these samples ; the results are summarized in Table IV : only in planting system IXB were the effects of treatments significantly different. Inspection of the full data showed no indication that the 1955 treatments had had a residual effect.

TABLE IV.

DISTRIBUTION OF FRUIT RUSSET ON SAMPLES, OCTOBER 4, 1956.

Planting system	1956 post-blossom fungicide	No. fruit russeted in each category			Category (A) as percentage of total
		(A) <10%	(B) 10% to 25%	(C) >25%	
IIA ..	Lime sulphur	158	13	—	92
	Captan	151	17	—	90
IIB ..	Lime sulphur	150	16	2	89
	Captan	150	13	—	92
IXB ..	Lime sulphur	144	19	3	87 **
	Captan	144	3	1	97 **

** Differ significantly at the 1% level.

Crop weight results, omitting data from replants, are summarized in Table V. There was a significantly greater yield on captan-treated plots in planting system IIA ; in the other two planting systems the yield on captan-treated plots was larger, though not significantly so. However, the very small number of experimental plots makes it impossible to detect as significant all differences which may be of economic importance, and the increased yield (of the order of 25%) on captan-treated plots in the planting systems IIB and IXB is therefore of interest.

There is little evidence of residual effects.

TABLE V.

MEAN CROP WT. (LB. PER TREE) EXCLUDING REPLANTS, OCTOBER 3, 1956.

Block	Post-blossom fungicide			Planting system		
	1954	1955	1956	IIA	IIB	IXB†
1	LS	LS	LS	140.0	113.4	52.3
	C	C	C	201.8	132.7	43.0
2	LS	C	C	181.0	177.8	49.5
	C	LS	LS	93.0	95.3	29.0
3	C	LS	C	146.9	85.4	47.2
	LS	C	LS	109.0	74.6	29.9
Overall mean for 1956 treatments			LS	114.0 *	94.4	37.1
			C	176.6 *	132.0	46.6

* Differ significantly at the 5% level.
† Picked Sep. 26.

Commercial grading was carried out on October 10 on the bulked crop. Data for fruit size and colour are summarized in Table VI, averaged for all blocks within each planting system. There are no consistent trends, and statistical analysis has not been carried out at this stage. It is noteworthy that the increased crop following captan is not associated with a reduction in fruit size.

TABLE VI.

GRADING DATA : FRUIT SIZE AND COLOUR.

MEAN PERCENTAGE FIELD CROP IN EACH CATEGORY, OCTOBER 10, 1956

Planting system	Post-blossom fungicide (1956)	Total fruit of at least "Fancy" grade	"Fancy" fruit graded for size		Fruit of "Fancy" size, but below standard for colour	3rd grade (small, green, blemish, culls)	Loss in Store
			>2¼ in. diam.	<2¼ in. diam.			
IIA	LS	51.4	34.4	17.0	13.7	31.4	3.5
	C	47.5	29.8	17.7	11.3	38.6	2.6
IIB	LS	61.3	44.7	16.6	10.6	25.2	2.9
	C	54.5	40.5	14.0	17.0	26.2	2.3
IXB	LS	52.8	41.3	11.5	10.6	33.4	3.2
	C	54.6	45.2	9.4	21.8	20.4	3.2

Discussion.

The 1956 results follow the general trends of those of 1955 : the substitution of captan for lime sulphur in the post-blossom spray programme on Cox's Orange Pippin was followed by an increase in crop that was again statistically significant in planting system IIA, and by a significant reduction in fruit russet on type IX rootstock ; there was little difference in scab level, which was again very low, or in crop grading data. Elsewhere in this Report (5) the results of pomological studies carried out on Block 2 of this experiment are given. They show clearly that the early and late fruit drops were significantly less on the captan-treated plot than on the plot receiving lime sulphur throughout, and that this is probably the primary cause of the increased crop ; there was little difference in the figures for "June drop". In addition, a greater proportion of fruit bud developed into blossom trusses on the captan-treated plot, indicating that the previous year's treatments, which in this block were the same as those in 1956, had had a residual effect.

The results for apple mildew differed from those of 1955, when post-blossom sprays had comparatively little effect on mildew level in the autumn. Despite the comparatively high level of infection on shoots of the current season's growth in September 1955, there was little evidence in May 1956 of any substantial overwintering inoculum and, as in 1955, infection of blossom trusses was negligible. The disease built up quickly, however, and late-summer infection was significantly greater on captan-treated plots ; the plots receiving lime sulphur at all stages in the three seasons 1954-56 again showed the lowest

incidence of the disease. The economic significance of the high August figures for mildew on the captan plots will be more accurately assessed at blossom time in 1957 ; as in the two previous seasons it may bear little relationship to the data of the previous autumn.

During 1957 it is proposed to apply a uniform spray treatment over all plots and, following a further assessment of disease and crop data, the trial will be analysed as a whole. It is hoped to publish a summary of the conclusions in the Annual Report for 1957.

In 1956 at Long Ashton, therefore, the gain in crop and, on type IX, in quality following the use of captan in the post-blossom sprays almost certainly outweighed the possible adverse effects of increased mildew attacks. It should be emphasized, however, that such results are unlikely to be representative of the drier parts of the country.

Summary.

In 1956, the final year of a three-year trial, the level of apple scab (caused by *Venturia inaequalis*) was very low following post-blossom applications of either captan (0.075%) or lime sulphur (0.75%), with a single pre-blossom lime sulphur spray throughout.

There were indications of a heavier crop and, on type IX, of less fruit russet following the use of captan. The use of this fungicide was followed by a high level of apple mildew (caused by *Podosphaera leucotricha*) on shoots of the current season's growth, though the economic importance of the attack may be small.

Acknowledgments.

The authors wish to thank Mr. E. W. Hobbis and Mr. E. Catlow for placing the trees at their disposal and for supplying detailed crop and grading data, Mr. R. W. Marsh for his continued interest, and Miss N. M. Waugh, Mr. R. T. Burchill and Mr. R. O. Sharples for assistance in recording. The meteorological data were kindly supplied by Mr. G. E. Clothier from the Station records.

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SPRAYING TRIALS AT LONG ASHTON 1953-1956 FOR THE CONTROL OF GLOEOSPORIUM STORAGE ROT IN ALLINGTON PIPPINS.

By R. W. MARSH and K. L. EDNEY*.

The susceptibility of Allington Pippin apples to lenticel spotting has long been recognized (2). Wilkinson (10) showed that storage rots following this lenticel spotting were preponderatingly due to infections by *Gloeosporium album* and *G. perennans*, initiated before the fruit was picked.

The possibility of reducing *Gloeosporium* infection by late-summer orchard spraying was first explored at Long Ashton in 1953, when a suitable block of Allington Pippin trees became available, and the Ditton Laboratory offered facilities for making the necessary storage tests. In consequence of the encouraging results of the 1953 trial, experiments were also made in other areas from 1954 onwards, using the more important variety Cox's Orange Pippin (Marsh, Montgomery and Edney, 1957). Meanwhile the Long Ashton trial on Allington was continued until 1956 to provide additional data on the effect of weather and of spray timing.

Experimental.

Description of plot. All the trials reported below were made on Plot 8a in the Long Ashton plantations. This was planted in 1920–22 with alternate rows of Allington Pippin and King Edward VII, all on Malling I rootstock, at 15 ft. on the square. In 1941/42 the plot was thinned to a 30 ft. quincunx. The trees were in arable cultivation until the spring of 1955 when the plot was grassed down.

An account of the earlier manurial treatments given to Plot 8a has been published (9). It was shown that these treatments, with the exception of the no-manure plots (which were excluded from the present spraying trials), induced no differential effects on the incidence of storage rots. In the manurial programme from 1953 onwards, the nitrogen application to the whole plot in 1953 and 1954 was at the equivalent of 2 cwt. nitrate of soda per acre ; in 1955 and 1956, 3 cwt. sulphate of ammonia per acre was applied. All the trees received each year a routine lime-sulphur spray programme terminating 3 weeks after petal-fall.

For the comparisons of late-summer spraying treatments in 1953 56 the trees along the edges of the plot were not used, and the sprays were applied only to the northern 12 trees in each of the four inner Allington rows. The interplanted trees of Edward VII were not sprayed, but served to reduce spray drift. In 1953 two 4-tree units were used for each treatment and six for the control. In each subsequent year the 48 trees were divided into 4-tree blocks, with the treatments randomised afresh in each block, thus giving 12 replicates. Figure 1, showing the arrangement of treatments in 1956, illustrates this lay-out. The allocation of the treatments to individual trees in each year after 1953 was designed to compensate for any residual effects from the previous season's sprays.

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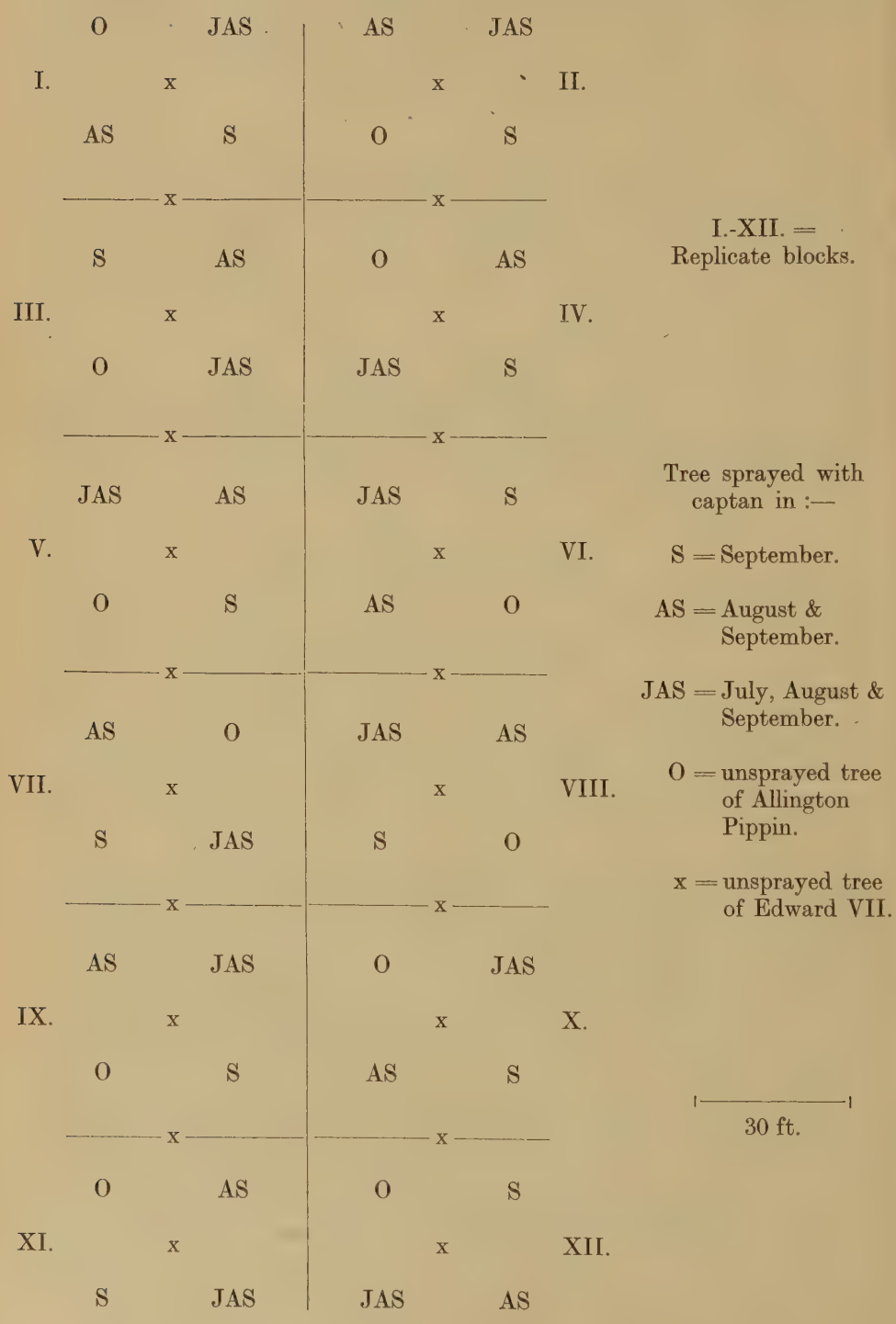
Fig. 1. Lay-out of Spraying Trial on Plot 8A, 1956.


O JAS AS JAS
I. x x II.
AS S O S
S AS O AS
III. x x IV.
O JAS JAS S
JAS AS JAS S
V. x x VI.
O S AS O
AS O JAS AS
VII. x x VIII.
S JAS S O
AS JAS O JAS
IX. x x X.
O S AS S
O AS O S
XI. x x XII.
S JAS JAS AS
I.-XII. = Replicate blocks.
Tree sprayed with captan in :—
S = September.
AS = August & September.
JAS = July, August & September.
O = unsprayed tree of Allington Pippin.
x = unsprayed tree of Edward VII.
30 ft.

Weather and yields. The four-year period included three cool, wet summers and one (1955) that was dry and warm. The relevant monthly rainfalls (in inches) were as follows :

	June	July	August	September	October
1953 ..	2.15	4.12	5.36	3.48	2.86
1954 ..	4.29	4.05	3.32	6.08	4.31
1955 ..	2.59	0.15	0.64	1.34	1.42
1956 ..	2.78	4.26	7.97	3.55	1.40

In 1954 and 1956 the crop was plentiful : in 1953 it was light and in 1955 very light.

Choice of spray treatments. Previous experience on Plot 8a had shown that the routine programme for apple scab control (lime-sulphur applications terminating in June) had no apparent effect in reducing *Gloeosporium* storage rot It was therefore decided to test late-summer applications of a number of fungicides, the final spraying being approximately 1 month before the picking date (mid-October). To avoid any objectionable residues, copper and mercury sprays were not included in the trial, nor was lime-sulphur, because its toxicity towards *G. perennans* and *G. album* spores had been shown by laboratory tests to be low.

The three fungicides selected for trial were :

Captan : used as a 0.2% suspension of a dispersible powder containing 50% captan.

Ziram : 0.25% of a dispersible powder containing 80% ziram.

Glyodin : 0.375% of a formulation containing 34% glyodin.

The final concentrations in the sprays applied were therefore : captan 0.1% ; ziram 0.2% ; glyodin 0.125%.

All applications were made as hydraulic, high-volume sprays applied with hand-directed 3-nozzle brooms delivering 5-6 gal. per minute at approximately 350 lb. pressure.

Picking and sampling. In each year the crop was picked about mid-October, any fallen apples being discarded. For each tree, all the fruits were picked into orchard boxes, which were sampled by taking equal numbers of apples from the corners to make up, in 1953, 2 bushels, and in subsequent years approximately 100 fruits. Within 48 hours of picking, the samples were delivered to the Ditton Laboratory for storage trials.

Storage methods. In 1953, 100 fruits were taken for cold storage from each 2-bushel sample made up in the orchard from the four-tree plots. This gave a total of 200 fruits for each treatment. These samples were stored in air in wooden trays at 40°F. and were examined on four occasions. In subsequent years the samples of 100 fruits were subdivided into four samples of 25 which were stored in paper bags at 37°F. Each sample was examined on one of four occasions and then discarded. Thus, for each examination, 12 samples of 25 were inspected from each treatment. The figures given below show the mean percentage fruits developing storage rots at the dates of examination, without discriminating between infections by *G. perennans* and those by *G. album.*

Results.

1953–4. In the first season two late-summer spraying dates were selected arbitrarily and three fungicides were compared, all being applied on both dates. The apples were picked on 13 October and stored at Ditton at 40°F.

The summarized results are as follows :

Percentage fruits developing storage rots, 1953–4.

Spraying dates	Fungicide	Records on : 1 Dec.	8 Dec.	29 Dec.	12 Jan.
17 Aug. and 10 Sept.	0.1% captan	4	6	17	30
	0.2% ziram	10	12	14	27
	0.125% glyodin	17	21	31	58
—	nil.	24	34	48	66

This preliminary trial showed, in comparison with the control, a marked reduction of storage rots following the two sprayings with either captan or ziram. Glyodin was much less satisfactory and was not used in subsequent trials.

1954–5. The purpose of the 1954 spraying was to determine the relative merits of an August and a September treatment and of a combination of the two. The same fungicide (captan) was used throughout. The crop was picked on 20 October and gave the following results :

Percentage fruits developing storage rots, 1954–5.

Spraying dates	Fungicide	Records on : 6 Dec.	20 Dec.	4 Jan.
16 August ..	0.1% captan	11.1	21.3	27.2
22 September ..		9.1	15.4	21.2
16 Aug. and 22 Sept.		7.2	12.4	17.5
—	nil.	18.5	32.5	41.4

Statistical examination of these results demonstrated that the single spraying in September gave a consistent significant reduction in percentage storage rots, compared with the controls, throughout the period of recording ; the August spraying gave a significant reduction only at the first count ; the twice-sprayed trees showed the cumulative effect of the two applications.

1955–6. In the 1955 trial the August-only treatment was omitted : otherwise this was a repeat of the 1954 experiment, made on a light crop in a much warmer and drier season. The crop was picked on 7 October : the results were as follows :

Percentage fruits developing storage rots, 1955–6.

Spraying dates	Fungicide	Records on : 17 Dec.	7 Jan.	4 Feb.
20 Aug. and 17 Sept.	0.1% captan	0.7	1.5	1.2
17 September ..		1.0	2.5	4.8
—	nil.	3.7	6.2	7.6

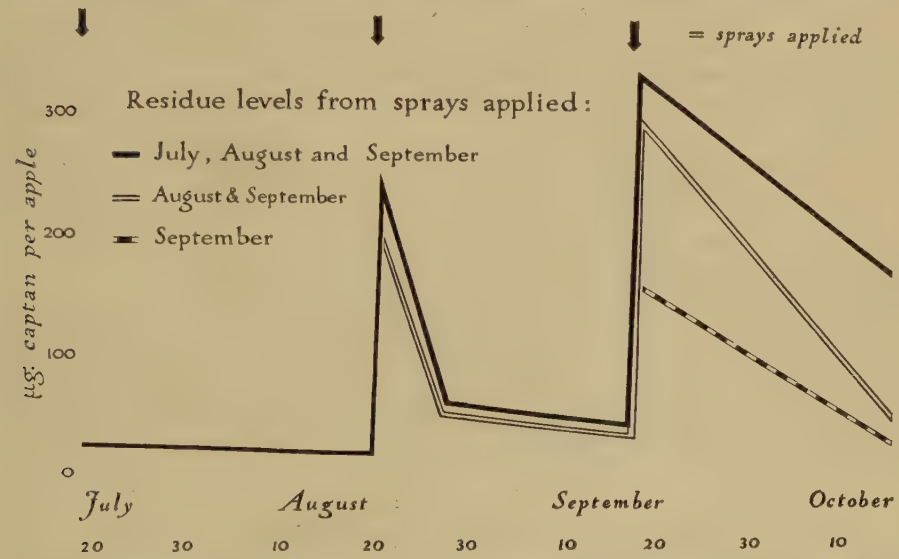
The much lower level of infection in 1955 is apparent from the above table. Otherwise the results corroborated those of 1954 in showing that a spraying in September gave a significant reduction in *Gloeosporium* infection and that this effect was enhanced by the addition of an August application.

1956–7. The final experiment in this series was made to compare the cumulative effects of three sprayings (July, August and September) with those of spraying in August and September and in September only. Captan was used throughout and the levels of captan residue on the fruit were determined before and after each spraying and immediately after picking. The figures obtained are quoted on p. 113.

Levels of captan deposit on fruit in parts per million
(JAS=sprayed 18 July, 21 August and 18 September ; AS—sprayed 21 August and 18 September ; S—sprayed 18 September ; O—no captan spray.)

Treatment	Date of recording					
	19 July	20 Aug.	21 Aug.	17 Sept.	18 Sept.	16 Oct.
JAS	1.45	0.31	6.77	0.74	6.17	2.20
AS	—	—	5.57	0.63	5.29	0.65
S	—	—	—	—	3.08	0.34
O	0.05	—	—	—	0.01	0.04

The corresponding values in micrograms per fruit are represented below.



The summer rainfall was heavy (July 4.26, August 7.97, September 3.55 in.) and the table shows that the loss of deposit by weathering in the inter-spray periods was high : nevertheless the residual effects of the early applications were apparent when the final analyses were made on 16 October.

The 1956 crop was harvested on 15 October and stored until March. The results were as follows :

Percentage fruits developing storage rots, 1956–7.

Spraying dates	Fungicide	Records on :			
		19 Dec.	9 Jan.	6 Feb.	6 Mar.
18 July, 21 Aug. & 18 Sept.	0.1% captan	0.3	1.7	0.7	4.8
21 Aug. & 18 Sept. ..	0.1% captan	0.7	2.0	1.7	8.6
18 Sept.	0.1% captan	0.7	2.7	4.7	9.0
—	nil.	0.7	2.7	6.0	8.4

1956 was again a year of low fruit infection on this plot and the storage records in December and January showed no significant effect of the sprays. On 6 February the AS and JAS treatments were significantly better (P—0.05) than the September-only treatment, which was not significantly better than the controls. At the count on 6 March only the JAS treatment showed a significant advantage.

At no time during the four-year trial was any adverse effect of the spray applications observed.

Discussion.

Within the past three years, investigations by Corke (3, 4) and Edney (5) have provided additional information on the sources of *Gloeosporium* infection of fruits. Both authors have shown that apple shoots cankered by *G. perennans* develop fructifications that produce conidia in the period May–October and that these spores are disseminated by rain washing and splashing. Edney has also shown (5) that *G. perennans* can grow and produce spores on dead apple leaves.

The wood of the Allington trees on Plot 8a at Long Ashton was almost free from large *Gloeosporium* cankers, but sources of infection were found on small dead stubs and pruning snags. In the summer of 1956 16% of the stubs and snags collected produced spores of *G. perennans* and 6% produced spores of *G. album*.

Washings from the leaves on the Allington trees showed small numbers of spores of both species at the end of July and an increase in September. Washings of fruits showed a high concentration of *G. perennans* spores on the skin in September, but fewer in October : only a small number of *G. album* spores were recorded (8).

These observations suggest that *Gloeosporium* spores were being disseminated in the trees from July onwards, becoming most plentiful in September. Edney (5), working with Cox's Orange Pippin, showed that resistance to *Gloeosporium* infection was high in young apples but fell as the fruit approached maturity. The combination of fruit susceptibility and abundance of spore inoculum that occurs in the late summer explains the significance of the pre-harvest period in the development of a *Gloeosporium* attack.

In the four-year period of the trial on Allingtons at Long Ashton, records in cold store taken not later than the first week of February showed a consistent reduction in *Gloeosporium* attack as a result of double spraying in August and September. In the 1956–7 season, when storage was extended to March, protection to the end of this period was given only by a programme of three sprayings, in July, August and September. The extended protection might have been due to the build-up of a higher deposit of captan on the harvested apples but more probably reflects the prevention of initiation of infections in July.

The efficacy of single sprays in August and in September has varied with the season. In the second and third year of this trial a single spraying in September was advantageous, but this treatment failed in 1956. A single spraying in August was tried in 1954, when it showed a beneficial effect only up to December 6th.

It should be noted that the dates given apply to the late-harvested variety Allington and may not be valid for Cox.

A comparison of the records for the four seasons of the trial at Long Ashton brings out the much higher incidence of *Gloeosporium* infection in the first two years of the experiment. For example, the January records of percentage rotted fruit from the unsprayed plots in the four successive years were 66, 41.4, 6.2 and 2.7 respectively. The low figure (6.2%) in the 1955–56

trial might be accounted for by the warm, dry summer of 1955; this explanation would not, however, be valid for the following year. Another possibility is that the succession of late-summer spray applications on the plot steadily reduced the supply of *Gloeosporium* spores. No evidence in support of this hypothesis has been obtained, and the washing tests made on the apples in 1956 showed large numbers of spores on the skins of the fruit.

The remaining factor to be considered is the cultural management of the plot. In this, the only change made in the 4-year period was the grassing-down carried out in the spring of 1955. Results published by the East Malling and Ditton stations (Montgomery, 1955; Anon, 1956) indicate that apples produced in grass orchards are in general less susceptible to *Gloeosporium* storage rots than fruit from cultivated plantations. It appears probable that the grassing-down of the Allington plot at Long Ashton in 1955 was the major factor in reducing the susceptibility to *Gloeosporium* attack of the fruits harvested in 1955 and 1956. The results of the trial as a whole indicate that both appropriate orchard management and late-summer spraying are able to play a part in reducing fruit-rotting caused by *Gloeosporium*.

Summary.

In a four-year trial on Allington Pippins at Long Ashton a programme of double spraying, in mid-August and mid-September, with 0.1% captan consistently reduced the incidence of *Gloeosporium* rotting of the crop stored until February. The level of control in 1956 was further improved by spraying also in July. Single sprays in August and September gave inconsistent results.

There was a marked reduction in infection coincident with the change from arable cultivation of the plot to a grass cover.

Acknowledgments

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SOME OBSERVATIONS ON THE EFFECTS OF FUNGICIDES ON ENZYME SYSTEMS IN *BOTRYTIS CINEREA*.

By E. C. HISLOP*.

Studies of the mode of action of fungicides have shown that an important mechanism of their toxic effect is the inhibition of fungus enzymes (2). In the current investigation the effects of four fungicides on enzymes in *Botrytis cinerea* Pers. were studied. The results show that drastic derangement of fungus enzymes can be caused by certain fungicides, thus confirming the findings of Byrde, Martin and Nicholas (2) with *Sclerotina laxa* Aderh. and Ruhl.

Materials and Methods.

Fungus. *B. cinerea* was isolated from Hydrangea and subcultured on malt agar in McCartney bottles. Slopes of potato agar inoculated with spore suspensions of the fungus were incubated for 12 to 14 days at 25°C. Thick spore suspensions were prepared from these slopes by transferring spores to 20 ml. sterile glass-distilled water with a platinum needle. The spore inoculum was transferred aseptically to the culture solution at the rate of 0.5 ml./50 ml. culture solution.

Culture Solution. The composition of the basal medium was as follows : dextrose, 40 g. ; peptone, 10 g. ; KNO_3, 0.1 g. ; KH_2PO_4, 6.8 g. ; $MgSO_4.7H_2O$, 2.5 g. ; $CaCl_2$, 0.1 g. ; $FeCl_3$, 0.02 g. ; distilled water to 1 litre. The culture solution was dispensed into 20 oz. medicine bottles which were laid flat in the incubator.

Fungicides. Four fungicides, copper sulphate, lime-sulphur, captan and *o*-phenyl phenol, were used, each at two concentrations found by trial to produce between 20 and 80 per cent. inhibition of growth when the fungus was incubated at 25°C. for 5 days. The concentrations in the culture solution were : copper sulphate ($CuSO_4.5H_2O$) 0.05 and 0.10% ; lime-sulphur 0.2 and 0.3% ; captan 5 and 20 p.p.m. ; *o*-phenyl phenol 6 and 7 p.p.m. The copper and lime-sulphur solutions only were sterilized at 5 lb./sq. in. for 20 min. before adding to the cultures. *o*-Phenyl phenol was dispensed in alcohol, and a similar amount of alcohol was added to the control cultures. The cultures were grown in two batches, each of which contained three replicates of one concentration of each fungicide ; these were placed in the incubator in random order.

Preparation of fungus extracts. The felts were collected in a Büchner funnel, well washed with distilled water, squeezed between layers of filter paper and weighed. They were put into a deep freeze unit at —17°C. for 12 hr. and were then ground in a mortar with three times their weight of cold 0.1 M phosphate buffer (pH 7.5). After being further homogenised in a Ten Broeck glass macerator at 0°C they were centrifuged at 2000 *g* for 10 min. at about 0°C. The supernatant was decanted and used as the enzyme source ; it contained between 80 and 90% of the enzymes.

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Enzymes. Catalase, peroxidase, cytochrome c oxidase, and alkaline phosphatase were determined in the extracts as described by Nicholas (5) :—

Catalase. 8 ml. 1.5% w/v $NaBO_3.4H_2O$ (pH 6.8) freshly prepared, 1.5 ml. 0.1 M phosphate buffer (pH 6.8) and 1 ml. enzyme extract were incubated in a 15 ml. centrifuge tube in a water bath at 37°C. for 5 min. after which 10 ml. $2N.H_2SO_4$ was added to stop the reaction. The solution was then titrated with 0.05 N $KMnO_4$. Blank determinations were made in which the H_2SO_4 was added at zero time. The catalase activity is expressed as millimoles perborate degraded in 5 min. per mg. protein (3).

Peroxidase. 1.3 ml. citric acid-phosphate buffer (pH 6.0), 1 ml. 10^{-3} M leucodye (2:6 dichloroindophenol reduced with palladised asbestos and hydrogen) and 0. 1 ml. enzyme extract were dispensed in a spectrophotometer cell and the endogenous rate of dye oxidation was followed for 1 min. at 625 mμ. Then 0.5 ml. 0.5% v/v H_2O_2 was added and the rate was followed for another 2 min. at 15 sec. intervals. The enzyme activity, corrected for endogenous rate, is expressed as the change in log I_0/I_1 of 0.001/min./mg. protein (6).

Cytochrome c oxidase. 1.5 ml. 0.2 M phosphate buffer (pH 6.8), 1 ml. leucodye and 0.1 ml. enzyme extract were dispensed in a spectrophotometer cell and the endogenous rate of dye oxidation was measured for 1 min., as for peroxidase. Then 0.5 ml. 10^{-4} M cytochrome c was added and the rate measured at 15 sec intervals for a further 2 min. The unit of activity is the change in log I_0/I_1 of 0.001 calculated between 15 and 75 sec./mg. protein (7).

Alkaline phosphatase. 1 ml. 0.2% w/v *p*-nitrophenol-phosphate and 0.1 ml. enzyme extract were incubated for 30 min. at 38°C. and the reaction stopped by adding 4 ml. 0.02 N.NaOH. The solutions were then centrifuged for 15 min. and their optical densities determined with a Spekker absorptiometer (0.5 cm. cells ; H_2O setting≡0.7 ; violet filters). A blank determination was always included in which the NaOH was added to the reaction mixture at zero time. The unit of activity is defined as μM *p*-nitrophenol-phosphate degraded/hr./mg. protein (1).

Protein was determined in the extract by Folin's method (4).

Results.

Data showing the effect of the fungicides on fungal growth and on enzyme activity are given in Table I as means for the three replicates of each treatment. The incorporation of the fungicides in the culture solution delayed the onset of growth, but at the lower fungicide concentrations there was a rapid recovery in growth rate, indicating that the fungus had become adapted to the lower levels of the toxicants. There was considerable variation between the depressions in yield of felt produced by identical amounts of fungicide.

Copper sulphate. Reductions of 20 and 70 per cent. in felt weight were obtained with 0.05 and 0.10% copper sulphate respectively. Whereas with the lower concentrations of copper the felts were of normal appearance, at the higher concentration the fungus grew only in small isolated colonies ; at an intermediate concentration of 0.07% the organism developed in strands.

At both copper concentrations catalase activity was depressed while cytochrome c oxidase and alkaline phosphatase were stimulated. The two copper levels had markedly different effects on peroxidase : whereas the lower level caused a threefold increase in activity, there was a 95 per cent. inhibition of activity at the higher level. This differential effect appears to be a function of concentration, since at the intermediate concentration of 0.07% copper sulphate, peroxidase activity was reduced by only 17 per cent., felt weight being 57 per cent. of the control.

Lime Sulphur. Lime-sulphur at 0.2% caused a reduction in felt yield of 50 per cent. whereas at 0.3% the reduction was only 40 per cent. ; this may be the result of differences in the two concentrates taken for dilution or of biological variation. Both levels had similar effects on enzyme activity : catalase and peroxidase were markedly depressed, and there was some depression of cytochrome c oxidase and alkaline phosphatase.

TABLE I.

THE EFFECT OF FUNGICIDES ON THE GROWTH AND ENZYME ACTIVITY OF *B. cinerea*.

Specific Activity of Enzymes †

Fungicide		Felt Weight as % Control	Catalase			Peroxidase			Cytochrome c oxidase			Alkaline phosphatase		
			Control	Treated	Treated as % Control	Control	Treated	Treated as % Control	Control	Treated	Treated as % Control	Control	Treated	Treated as % Control
Copper sulphate	0·05%	80	60	34	56	14,360	43,700	301	560	956	169	0·53	0·64	121
	0·10%	30	76	35	46	8,300	419	5	103	130	126	0·84	0·87	104
Lime sulphur	0·2%	50	107	37	34	15,260	1,100	7	270	200	73	2·35	1·19	50
	0·3%	60	45	10	23	2,260	599	27	226	102	45	0·48	0·39	81
Captan	5 p.p.m.	60	103	117	113	7,353	1,700	15	124*	320*	259	1·1	0·90	82
	20 p.p.m.	40	67	96	144	16,440	1,591	10	118	178	151	0·70	0·76	109
o-Phenyl-phenol	6 p.p.m.	70	54	8	15	2,620	195	7	15*	25*	169	0·33	0·46	139
	7 p.p.m.	45	54	11	20	2,620	229	9	15*	52*	347	0·33	0·42	127

† For units see text. * Dialysed 16hr. against phosphate buffer, pH 7·5.

Captan. There was a decrease in felt yield of 40 per cent. from 5 p.p.m. captan and a decrease of 60 per cent. from 20 p.p.m. At both concentrations the specific activities of catalase and cytochrome c oxidase were increased while that of peroxidase was greatly reduced ; there was little effect on alkaline phosphatase.

o-*Phenyl phenol.* The reductions in felt weight due to 6 p.p.m. and 7 p.p.m. *o*-phenyl phenol were respectively 30 and 55 per cent. At both concentrations there was a marked reduction in the production of catalase and peroxidase ; there was a notable stimulation of cytochrome c oxidase and some stimulation of alkaline phosphatase.

Discussion.

Lime-sulphur had a depressant effect on all the enzymes examined ; as with *S. laxa* (2) it was the only toxicant to reduce alkaline phosphatase. Depression of the three iron enzymes suggests that lime-sulphur may have some effect on haem-iron ; it caused a similar depression of the iron enzymes of *S. laxa*.

The activity of peroxidase was much greater in *B. cinerea* than in *S. laxa*. In the first organism it was greatly depressed by all fungicides except the lower level of copper sulphate, whereas in *S. laxa* marked depression was caused by lime-sulphur only. No stimulation of peroxidase, similar to that produced by 0.05% copper sulphate in *Botrytis*, was observed in *S. laxa*.

Captan depressed peroxidase and stimulated the other two iron enzymes whereas in *S. laxa* peroxidase and catalase were increased by this fungicide and cytochrome c was unchanged. In both fungi captan increased catalase production.

o-Phenyl phenol reduced catalase and peroxidase but greatly stimulated cytochrome c oxidase. A similar pattern of enzyme derangement occurred in *S. laxa* (2).

The work supports the view that the derangement of fungus enzymes is an important mechanism of the toxic action of fungicides. It is of interest that the activity of cell enzymes can be increased as well as depressed by toxicants, presumably because the regulatory mechanism of cell metabolism is adversely affected.

Summary.

(1) Catalase, peroxidase, cytochrome c oxidase and alkaline phosphatase were determined in extracts of *Botrytis cinerea* grown in culture solutions with copper sulphate, lime sulphur, captan and *o*-phenyl phenol.

(2) Copper sulphate depressed catalase and increased cytochrome oxidase ; it had little effect on alkaline phosphatase. At a concentration of 0.05% it stimulated peroxidase threefold but at 0.10% there was a depression to one twentieth of the control level. Lime sulphur depressed all four enzymes. Captan increased catalase and cytochrome c oxidase, and depressed peroxidase ; it had no effect on alkaline phosphatase. *o*-Phenyl phenol decreased catalase and peroxidase, and stimulated cytochrome c oxidase and alkaline phosphatase.

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BLACK CURRANT LEAF SPOT: A NOTE ON FURTHER LABORATORY TESTS OF FUNGICIDES ON OVERWINTERED LEAVES.

By A. T. K. CORKE.

Earlier results obtained by treating overwintered black currant leaves with fungicides in the laboratory, to prevent the maturation of ascospores of *Pseudopeziza ribis* in the spring, have already been described (1). Ascospore discharge was completely inhibited by 0·05 per cent. phenyl mercury chloride, 0·1 per cent. sodium pentachlorophenate and 0·1 per cent. sodium dinitro-*ortho*-cresylate, but the water-soluble sodium salts appeared to possess greater eradicant properties. It was also noted that the immersion of dead leaves in an aqueous solution (0·05 per cent.) of sodium DNOC in the laboratory gave much better results than spraying the leaves on the ground with DNOC at twice the concentration in an oil emulsion.

Laboratory tests have since been carried out with various formulations of DNOC, and also on the effect of the time of application on eradicant action.

Experimental.

Laboratory tests.

The methods of treating the leaves with fungicides in the laboratory, and of estimating the results, were as already described (1). In the winter of 1954-55 leaves were treated either on 14th December or 27th January, and in 1956 on 7th February.

Materials.

On 14th December 1954 two fungicides were used at three concentrations :

(a) Sodium salt of dinitro-*ortho*-cresol (a commercial preparation containing approximately 50 per cent. DNOC) as 0·2 per cent., 0·05 per cent. and 0·0125 per cent. aqueous solutions.

(b) Sodium pentachlorophenate (sodium PCP) as aqueous solutions at the same concentrations.

On 27th January 1955 these two materials were used as above and also at two additional concentrations, 0·1 per cent., and 0·025 per cent.

Tests were also made with 0·1 per cent. DNOC in 3 per cent. diesel oil emulsion, and with the emulsion alone, on 10th December 1954 and 18th February 1955. On 7th February 1956 five materials were used, each at the five concentrations used in January 1955.

(a) Sodium salt of DNOC (commercial preparation), as above.

(b) Sodium PCP, as above.

(c) Sodium DNOC, as aqueous solutions freshly prepared from DNOC (90% pure) and sodium hydroxide.

(d) Ammonium DNOC, as aqueous solutions freshly prepared from DNOC (90% pure) and ammonium hydroxide.

(e) DNOC in 3 per cent. diesel oil emulsion.

Results.

The inhibition of ascospore discharge following treatment with the sodium salt of DNOC (material (a)) and sodium PCP was complete at all concentrations above 0·05 per cent., at which concentration the minimum possible discharge was recorded for both materials. At lower concentrations treatment with sodium PCP had progressively less effect than that with sodium DNOC (a). Treatment with ammonium DNOC was almost equivalent in effect to sodium DNOC (a). This latter material, however, was not as effective as the freshly prepared sodium DNOC (c) or the DNOC in 3 per cent. diesel oil emulsion, both of which gave complete inhibition of spore discharge at all concentrations.

Complete inhibition also followed the application by spraying of 0·1 per cent. DNOC in 3 per cent. diesel oil emulsion to only one surface of both wet and dry leaves, while the application by immersion in diesel oil emulsion alone rendered leaves less readily wettable but had no effect whatever on ascospore discharge.

Discussion.

Over a period of three years the immersion of overwintering black currant leaves in 0·1 per cent. solutions of sodium PCP and sodium DNOC has effectively prevented the maturation of ascospores of *Pseudopeziza ribis*. The experiments described here indicated that whereas sodium PCP was ineffective at 0·0125 per cent., three formulations of DNOC caused some inhibition at this concentration.

Complete inhibition of sporulation was also achieved by spraying one surface of both wet and dry leaves in the laboratory with 0·1 per cent. DNOC in 3 per cent. diesel oil emulsion, and by immersing leaves in considerably lower concentrations.

An application of DNOC to the bushes before general defoliation has already been suggested as a possible means of obtaining adequate dispersal of this fungicide on leaves in the field (1).

If DNOC were as effective as an eradicant against *P. ribis* on green leaves as it is on dead leaves, the use of a 0·025 per cent. preparation, for example, would lessen considerably the possibility of toxic effects on both the operator and the bushes.

Summary.

Laboratory tests were continued with two fungicides previously found to prevent the maturation of ascospores of *Pseudopeziza ribis* on overwintered black currant leaves. Aqueous solutions of sodium pentachlorophenate and sodium dinitro-*ortho*-cresylate (commercial preparation) were again effective at 0·1 per cent., but whereas sodium PCP rapidly became ineffective following dilution to 0.0125 per cent., sodium DNOC continued to exert some inhibitory effect. Freshly prepared aqueous solutions of sodium DNOC and ammonium DNOC gave complete inhibition at 0·0125 per cent. and 0·025 per cent. respectively.

Although complete inhibition of sporulation followed the laboratory treatment of dead leaves with 0·0125 per cent. dinitro-*ortho*-cresol in 3 per cent. diesel oil emulsion, no control resulted from the use of the same material at 0·1 per cent. as a ground spray applied in the field on 15th December or 16th February. The oil emulsion alone was not fungicidal in the laboratory trials.

Acknowledgments.

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SPRAY APPLICATION PROBLEMS: XXXI. THE DETERMINATION OF SULPHUR DEPOSITS ON FOLIAGE.

By V. D. KRENTOS*, R. F. BATT and J. T. MARTIN.

Introduction.

Recent developments in the concentrate and small-volume spraying of lime sulphur for apple scab and mildew control have focused attention on the need for a method of determination of sulphur on plant tissues. Moore (1) has concluded that these diseases can be controlled, under experimental conditions, at least as well and as safely by appropriate air-blast applications of undiluted lime sulphur, at the rate of about 6 gal./acre, as by normal hydraulic application of the diluted fluid. Kearns, Marsh and Morgan (2), on the other hand, failed to obtain satisfactory scab control by applications of either 2 or 4 per cent. lime sulphur, at 55 gallons per acre per application, to large bush trees of Cox and Worcester. The results of scab control trials such as these are difficult to interpret in the absence of information on the

* On study leave from the Department of Agriculture, Government of Cyprus.

amount and distribution of fungicide per unit area of plant surface necessary to control the disease, or on the deposits resulting from different methods of application. To obtain answers to these questions, attention was given to a method of analysis for sulphur deposits that would be sufficiently sensitive for distribution studies.

Allen and Llewelyn (3) estimate lime sulphur on whole leaves from the calcium content of deposits obtained by titration with disodium ethylenediamine tetra-acetate. In the search for a method suitable for the analysis of small leaf discs, preliminary work showed that neither the test for sulphur developed by Feigl and Stark (4), which is based on fusion with benzoin, nor the reaction of sulphur with benzylimino-di(*p*-methoxyphenyl) methane used by Schonberg (5), was likely to be useful for its quantitative determination. The reduction of the sulphur to hydrogen sulphide, as carried out by Johnson and Nishita (6), followed by the conversion of the hydrogen sulphide to methylene blue, was then investigated and found to be satisfactory. The methylene blue reaction has already been used for the determination of cystine and other disulphides (7) and of hydrogen sulphide formation from dithiocarbamate (8).

The method developed determines the sulphur present in deposits on leaf discs as the element or in an oxidized form such as sulphate, over the range of 0-25 micrograms.

The Method of Analysis.

Details of the method are as follows :

Add the leaf disc (0·5 or 1 sq. cm. area) to a mixture of hydriodic acid (S.G. 1·7, 5 ml.), formic acid (S.G. 1·22, 3·8 ml.) and red phosphorus (0·75 g.) contained in a 100 ml. B.14 round-bottom flask provided with a side inlet tube and vertical 6″ Liebig reflux condenser. Bubble nitrogen gas (washed by passage through 4 N sodium hydroxide solution) through the mixture and simmer gently. Conduct the gas from the condenser into a 25 ml. graduated cylinder containing 20 ml. of zinc-sodium acetate solution (5 per cent. zinc acetate-1·25 per cent. sodium acetate : 5 ml. diluted in the cylinder to 20 ml. before the test). The glass tube leading the gas into the cylinder is detachable so that it may be left in the cylinder.

After 15 minutes, remove the cylinder and enclosed tube, add dimethyl-phenylenediamine dihydrochloride solution (0·1 per cent. in 18 per cent. W/W hydrochloric acid, 1 ml.), stopper immediately, shake and stand for 10 minutes. Add ferric chloride (2 per cent., 0·2 ml.), shake and stand for 15 minutes. Remove the glass tube from the cylinder and wash, make up to 25 ml. with water and measure the optical density of the methylene blue spectrophotometrically. Maximum colour development is attained after 15 minutes, and the colour is stable for a long period.

Using the Unicam S.P. 600 instrument, set at 670 mμ, a 0·5 cm. cell and the red-sensitive photocell, the values for the calibration curve were as follows :

Sulphur μg.	*Optical Density*
0	0·012
5	0·089
10	0·181
15	0·253
25	0·418

Ground glass connections should be used in the apparatus. Tests have shown that a second absorption cylinder is not necessary, provided the gas bubbles through a depth of zinc acetate solution of about 10 cm. Zinc sulphide may adhere to the wall of the tube conducting the gas into the cylinder and may be lost if the tube is removed from the cylinder before acidification with the amine solution.

Care must be taken to remove sulphur from the reducing mixture before the test. A bulk supply of the mixture may be freed from sulphur by simmering under reflux with the passage of nitrogen. Since the reaction flask used in a test may also be contaminated, it is preferable to treat individual batches of 10 ml. of mixture. The reaction is carried out for 30 minutes, the absorption tube is changed and the process continued for 15 minutes with a test to ensure that all sulphur contamination has been removed. The mixture is cooled, a leaf disc added, and the analysis made. Five successive tests may then be carried out with each 10 ml. of treated reducing mixture. The acid amine solution should be kept in the dark, and used only within one week of preparation.

The method has been used successfully to follow the levels and distribution of deposits on apple foliage treated with lime sulphur. When applied at 2 per cent. strength, a mean deposit of 43 μg.S/sq. cm. was obtained, with marked irregularity of distribution (percentage coefficient of variation V = 40 per cent.). The addition of a wetter reduced the average deposit to 25 μg. S/ sq. cm. with an improvement in distribution (V = 23 per cent.).

Summary.

A method is described for the determination of sulphur in spray deposits on foliage. The method is designed for the analysis of small leaf discs in distribution studies.

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SPRAY APPLICATION PROBLEMS: XXXII. NOTE ON THE DETERMINATION OF SURFACE DEPOSITS OF COPPER FUNGICIDES.

By J. T. MARTIN.

The rapid method described in the last Report (1) for the assessment of deposits of copper fungicides has been used successfully in studies of the effect of the formulation of the fungicides on the deposits obtained on the foliage of black currant, pear, banana, coffee and other crops. The method is designed to permit the determination of copper on leaf discs of 1 sq. cm. area in order to follow the distribution of the fungicide over single leaves. From the analytical results, the distribution of the deposit is assessed numerically by calculation of the percentage coefficient of variation (V), given by $100\sigma/\mu$, where μ is the mean level of deposit per unit area and σ its standard deviation.

Further study of the method has been made by Dr. E. Somers and Mr. J. L. Garraway (2). They find that the blue complex formation with bis-*cyclo*hexanone oxalyldihydrazone is influenced by pH and the concentration of ammonium ions, and use a borate buffer solution to stabilize the pH within the range 8·3 to 8·9; under these conditions the colour development is rapid and complete. Using the modified method the estimation of copper at concentrations of 0-50 μg./ml. is unaffected by the presence of 100 μg. of Fe^{3+}, Ni^{2+}, Co^{2+}, Mn^{2+}, Mg^{2+}, Ca^{2+}, Zn^{2+}, Al^{3+}, CrO_4^{2-} and PO_4^{3-}. The use of the borate buffer has now been incorporated into the analytical method, the details of which are as follows:

Place the leaf disc (1 sq. cm. area) in a conical flask, add 10 ml. of N sulphuric acid and 1 drop of wetter (Teepol diluted with an equal volume of water) and allow to stand for 10 minutes with occasional swirling. Add 1 drop of neutral red indicator solution, 2·5 ml. of 10 per cent. ammonium citrate solution and 2·5 ml. of 4N sodium hydroxide solution previously standardized, to neutral red, against the acid solution. The acid should be just neutralized; if not, add a further one or two drops of the soda solution. Add 2·5 ml. of borate buffer solution (400 ml. of 0·05 M boric acid + 60 ml. of 0·5 M sodium hydroxide, pH = 8·1) and 2·5 ml. of bis-*cyclo*hexanone oxalyldihydrazone reagent (0·05 per cent. solution in 50:50 ethyl alchohol-water). Measure the intensity of colour development after 15 minutes.

Using the Unicam S.P. 600 spectrophotometer set at 595 mμ and a 1 cm. cell, the calibration curve values were as follows:

μg. Cu.	*Optical Density.*
10	0·127
20	0·252
30	0·377
40	0·508
50	0·633

To reduce the number of operations required, the sulphuric acid and the ammonium citrate may be added together at the beginning of the test and the

borate buffer and the reagent solution together after the neutralization with the sodium hydroxide solution. If this is done, the mixed solutions should be prepared immediately before use.

The method has been used for the determination of surface deposits, on leaves, of copper present as Bordeaux or Burgundy mixture, copper oxychloride, cuprous oxide or basic copper carbonate. The efficiency of the method in recovering copper from discs of banana and coffee leaves treated with Bordeaux mixture or cuprous oxide has been examined by ashing the discs after the test, followed by the determination of copper by the standard dithiocarbamate method. The highest residual value found was 0·5 μg. Cu from discs carrying original deposits of up to 28 μg. Cu/sq. cm.

The use of oxalyldihydrazide for the spectrophotometric micro-determination of copper has recently been described by Gran (3). An intense violet colour is given by copper in the presence of the reagent, ammonium hydroxide, and an excess of formaldehyde or acetaldehyde. The applicability of the test to the analysis of leaf discs has been examined, but the method, while of greater sensitivity, seems to confer no definite advantage over the use of the *cyclo*hexanone derivative.

Summary.

A modification of the method for the determination of surface deposits of copper fungicides on small leaf discs is described.

Acknowledgments.

I am indebted to Dr. Somers and Mr. Garraway for their work on the method and to Miss P. M. Jackson and Miss A. Tapscott for analytical assistance.

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SPRAY APPLICATION PROBLEMS: XXXIII. THE MICRO DETERMINATION OF DDT.

By R. F. BATT and J. T. MARTIN.

Introduction.

An earlier report (I) has given details of a method used for the determination of DDT in foliage, fruits and grain. The method was designed for the analysis of quantities of the order of 10 g. of fresh foliage, and 50 g. of fruits and grain, and was calibrated over the range 0–350 μg. of DDT. Extraction was made with carbon tetrachloride and, for foliage, surface and inside deposits were determined separately. Pigments and wax were removed by the passage of the solvent extract through activated alumina, the DDT was nitrated, and a blue colour formed with alcoholic potash.

Later, an account was given (2) of the determination of DDT and chlorbenside occurring together in spray deposits. Separation of the chlorbenside, which interferes in the determination of DDT by the above method, was effected by permanganate oxidation of the chlorbenside sulphide to the sulphone, which was retained on the alumina column. In this work, it was noticed that the permanganate oxidation, in combination with the alumina treatment, effectively eliminated interference in the analysis for DDT of some highly pigmented soil extracts for which the alumina process alone was scarcely adequate. In the analysis of small samples of plant material, the permanganate treatment by itself could be relied upon to reduce the blank determination on unsprayed material virtually to zero.

The determination of DDT on samples of 10 g. of foliage gives no indication of the distribution of DDT over the leaf surface. We therefore investigated the assessment of DDT on leaf areas of the order of 5 sq. cm. and on small fruitlets. Experience with the " macro " method described above showed that when an emulsion of high wetting properties of DDT at 0·025 per cent. was applied to apple foliage, a level of deposit of up to 2μg.DDT/sq. cm. could be expected. Proportionally higher levels would be given by the greater concentrations often used commercially. We therefore decided to work over the range of 0 30 μg. DDT, the leaf samples of 5 sq. cm. area providing levels of DDT conveniently within these limits.

In the " micro " method developed, no attempt has been made to distinguish between " surface " and " inside " deposits, acetone being used instead of carbon tetrachloride for the initial extraction. The permanganate treatment eliminates interference from plant extractives, essential when dealing with such low amounts of DDT. The method differs, too, from the " macro " method in the use of benzene instead of carbon tetrachloride for the separation of the nitro derivative, the whole of the benzene solution being used for the colour development.

The Method of Analysis.

The procedure in the micro method is as follows :

Extract five leaf discs (each of 1 sq. cm. area) by hot percolation with acetone for 15 minutes, and remove the solvent in a stream of air at 40°C. Add 4 ml. of acetic acid and 5 ml. of 2·5 per cent. potassium permanganate solution

and heat on a boiling water bath for 10 minutes. Cool and decolorize by the addition, drop by drop, of 5 per cent. sodium metabisulphite solution. Extract, with vigorous shaking, with 10 and 5 ml. portions of carbon tetrachloride. Run the carbon tetrachloride extracts through anhydrous sodium sulphate into a round-bottom flask, and remove the solvent to dryness in a stream of air at 40°C.

Add 1 ml. of nitration acid (mixture of equal volumes of sulphuric acid and fuming nitric acid) and heat in a boiling water bath for 10 minutes. Cool, add 5 ml. of water, and make just alkaline to litmus with 4 N sodium hydroxide solution.

Extract with vigorous shaking with 10 ml. of benzene. Wash the benzene layer with two lots of 3 ml. of water, run the benzene solution through anhydrous sodium sulphate into a 25 ml. graduated cylinder, wash the desiccant and adjust to 10 ml. with benzene and add 5 ml. of freshly prepared and filtered 5 per cent. alcoholic potash. Measure the optical density after 5 minutes.

The calibration line prepared from tetranitro-DDT (△), DDT nitrated as in the method (X), DDT taken through the entire method (O), and DDT present in leaf extract (□), using the Hilger Spekker Asorptiometer (Ilford 607 filter) and 2 cm. cell is shown in Fig. I.

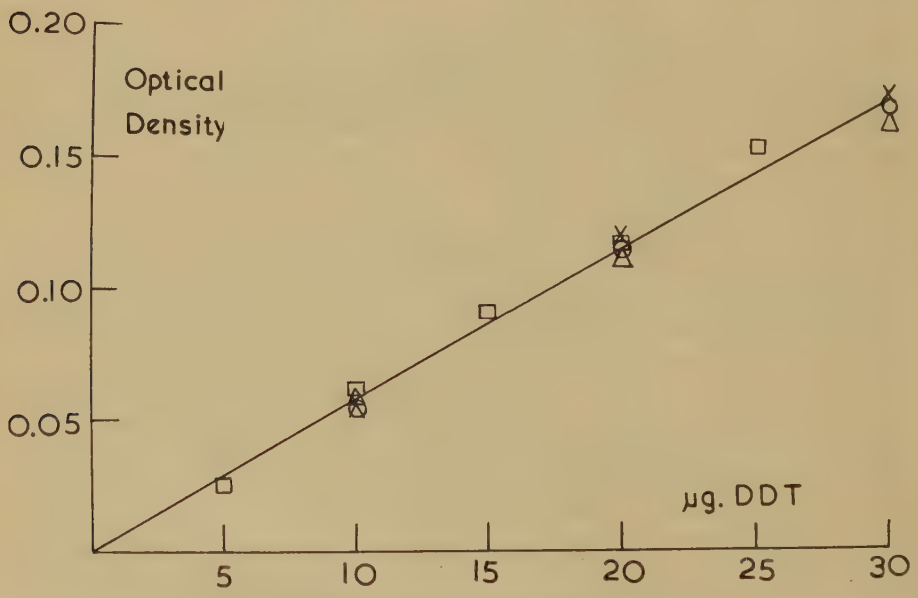

Fig. 1. Calibration curve for determination of DDT.

Recoveries of DDT by the method. Quantities of DDT up to 30 μg. were added to acetone extracts of apple foliage (3 sq. cm.), a sandy soil (5 g.), a soil rich in organic matter giving a highly pigmented extract (5 g.), and grain (5 g.). The recoveries found are given in Table I.

The recovery of DDT from acetone extracts of whole-meal flour was satisfactory only when a more stringent oxidation was employed, using larger quantities of acid permanganate than recommended above. The method has been used successfully to follow the distribution of DDT on foliage and fruitlets following hand, automatic and mist spraying of apple and pear trees.

TABLE I.

RECOVERY OF DDT BY THE MICRO METHOD.

	DDT added (μg.)										
DDT found (μg.)	0	5·0	7·5	10·0	12·5	15·0	17·5	20·0	22·5	27·5	30·0
Apple foliage ..	nil	5·0	—	11·3	—	16·5	—	20·8	—	27·5	—
Sandy soil ..	nil	—	7·0	—	11·3	—	15·3	—	22·2	27·7	—
Organic soil ..	nil	—	7·8	—	12·3	—	16·2	—	21·3	29·3	—
Grain	nil	—	—	9·8	—	—	—	19·7	—	—	30·8

The Determination of DDT in Soil.

Further work has been carried out on the recovery of DDT from soil by solvent extraction. The soil in which DDT had been incorporated was a sandy loam, freely drained, pH 6·2–6·4, and containing 2–2·5 per cent. organic matter. Samples were prepared for analysis by air-drying and passage through a $\frac{1}{8}$ in. square-hole sieve.

Extraction was carried out on 20 g. portions in three successive stages : by hot percolation with carbon tetrachloride (method (a)) ; by allowing the soil to stand overnight in a mixture of carbon tetrachloride and isopropyl alcohol (b) ; and, finally, by hot percolation with isopropyl alcohol (c). Two of the samples were also examined by hot percolation with isopropyl alcohol alone (method (d)). The solvents were removed from the extracts by a current of air at 40°C, the residues were taken up in carbon tetrachloride, passed through alumina, and the analysis was continued by the method described earlier (1). The results are given in Table II.

TABLE II.

RECOVERY OF DDT FROM SOIL BY SOLVENT EXTRACTION.
(p.p.m. air-dry soil)

Sample	*Extraction Method* (a)	(b)	(c)	(d)
31	4·0	0·4	1·4	5·9
32	4·5	0·5	1·3	6·5
33	1·5	0·3	0·4	—
34	1·4	0·3	0·2	—
49	1·9	0·4	0·3	—
50	1·6	0·6	0·1	—
51	2·1	0·5	0·3	—
52	1·9	0·8	0·2	—
Untreated ..	nil	nil	nil	nil

The results show that appreciable quantities of DDT were recovered by isopropyl alcohol after extraction of the soil with carbon tetrachloride.

A comparison was next made of the recoveries of DDT obtained using acetone extraction of 5 g. portions (method (e)); acetone extraction of 20 g. portions (f); and isopropyl alcohol extraction of 20 g. portions of soil (g). In these tests, duplicate analyses were carried out by the procedure of the micro method described above. The results, as DDT p.p.m. of soil, are given below.

	Extraction method		
Sample	(e)	(f)	(g)
145	2·4, 2·4	2·5, 2·4	2·5, 2·6
146	2·5, 2·6	2·4, 2·6	2·4, 2·5
147	2·3, 2·6	3·0, 3·0	2·6, 2·8
148	3·2, 2·9	4·3, 3·1	2·7, 2·6
Untreated	nil	nil	nil

The results of analysis by the micro method, using 5 g., agree with those from the analysis of 20 g. of soil using isopropyl alcohol for extraction. In the analysis of quantities of 20 g. of potting and garden soils rich in organic matter, permanganate oxidation may be needed, after the passage of the carbon tetrachloride solution of the original extract through alumina, to remove interference.

Summary.

A rapid micro-method, calibrated over the range 0–30 micrograms, for the determination of DDT on foliage and fruitlets and in soil and grain, is described.

Experiments are reported on the recovery of DDT from soil.

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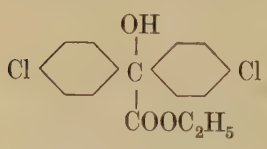
SPRAY APPLICATION PROBLEMS: XXXIV. THE DETERMINATION OF SPRAY DEPOSITS OF CHLOROBENZILATE.

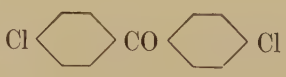
By E. J. SKERRETT and E. A. BAKER.

Introduction.

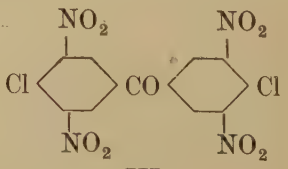
Chlorobenzilate is the common name given to the acaricide ethyl *pp'*-dichlorobenzilate (I) introduced by the Geigy Co., Ltd. in 1952. Interest in the relationship between the amount of spray deposit and its biological efficiency has led to an examination of methods for the determination of the acaracide on foliage.



I



II



III

Blinn *et al.* (1) separated the active material from interfering pigments and waxes in the plant extract by alkaline hydrolysis to the corresponding water-soluble sodium salt. Isolation of the free acid after acidification was followed by oxidation with chromium trioxide-glacial acetic acid mixture to di-(*p*-chlorophenyl) ketone (II). This compound was estimated from its absorption at 264 mμ or by the red colour given by its 2:4-dinitrophenylhydrazone in alkaline alcoholic solution. Harris (2) developed a method for apples and strawberry fruits in which the sample was extracted with benzene, the solvent evaporated and the residue nitrated. The tetranitrodichlorobenzophenone (III) formed was then dissolved in methanolic sodium methoxide to give a red colour whose absorption at 538 mμ was measured. Of the two methods the second appeared to be the more promising; it has therefore been developed and applied to the assessment of deposits on black currant foliage.

Experimental.

A sample of the 90% Geigy preparation was vacuum-distilled; the fraction boiling at 174-178°C/0·8 mm. solidified to give a solid, m.p. 37-38·5°C. after crystallisation from petroleum ether. This material was used to prepare the standard solutions used in the subsequent work. Its nitration product was shown to be identical with a specimen of di-(4-chloro-3:5-dinitrophenyl) ketone (III) prepared from 1:1-dichloro-2:2-di-(4-chlorophenyl) ethylene by the method of Backeberg and Marais (3).

The conditions for nitration were examined, and it was found that the initial slow heating suggested by Harris (2) could be omitted; though it was necessary to retain a heating period of 1 hour at 100°C. After nitration the flask was cooled in an ice-water bath, and its contents diluted with saturated sodium sulphate solution, as this gave cleaner separations and reduced the solubility of the ether in the aqueous phase. Ether was preferred to benzene as it was more readily removed in the evaporation stage. The elimination of acidic components from the ethereal solution was best achieved by washing with 25 ml. and 10 ml. of 5 per cent. potassium hydroxide. A yellow-brown coloration appearing in the first wash was attributed to decomposition products of the stearic acid used in the procedure.

The methanolic sodium methoxide used for colour development in the original method was replaced by 5% methanolic KOH solution, which is more readily prepared. The colour intensity given by this reagent was almost independent of the concentration of alkali over the range 5-9 per cent. The use of 538 mμ was confirmed as the most suitable wavelength for use in the measurement of optical density (Fig. 1), as plant pigments interfered in the region of the other peak at 425 mμ. The maximum colour developed after 30 minutes. Comparisons with equimolecular quantities of the tetranitrobenzophenone indicated recoveries of 95-97% chlorobenzilate in the method. The calibration curve for chlorobenzilate is shown in Fig. 2.

In the preparation of plant extracts, carbon tetrachloride was preferred to the benzene used by the American workers, as traces of the latter solvent had to be most carefully removed : otherwise its nitration products gave rise

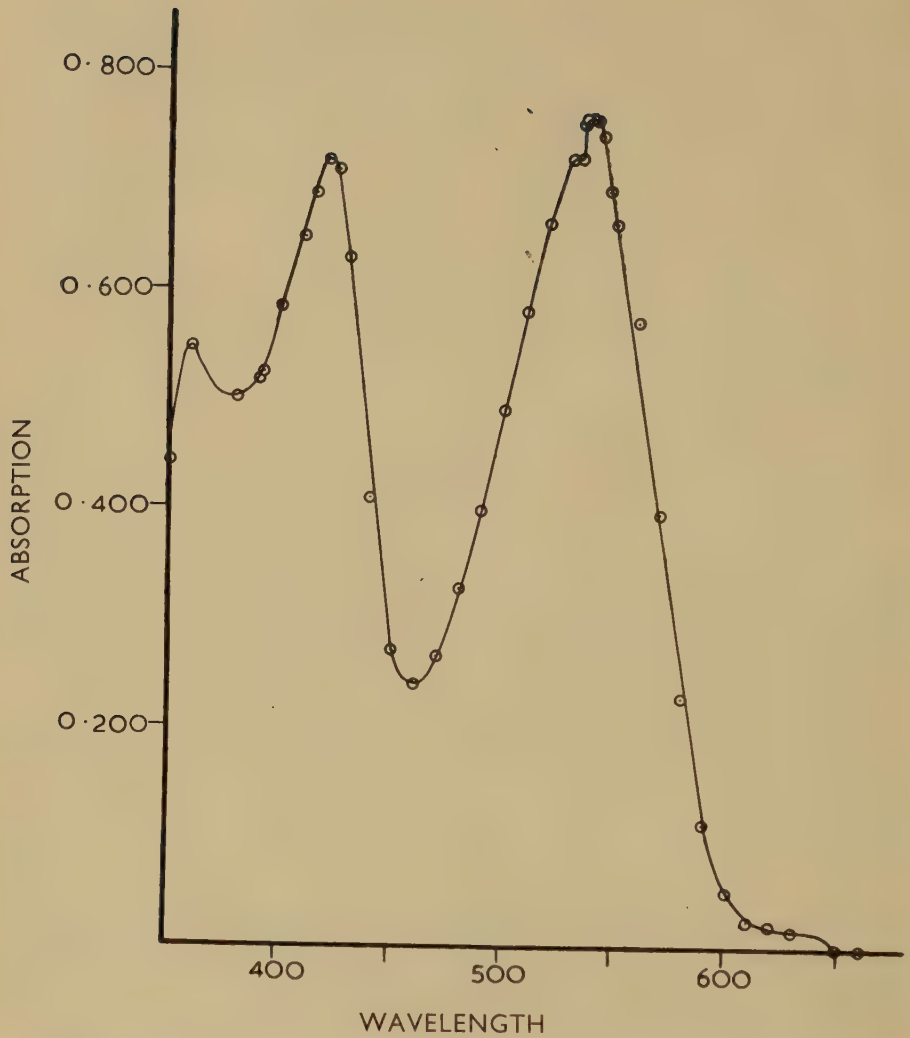


Fig. 1. Absorption spectrum of tetranitro-dichlorobenzophenone in alkaline solution.

to erroneous results. Known quantities of the acaracide were added to the carbon tetrachloride solution and the results below indicate satisfactory recoveries with little interference from plant pigments.

Chlorobenzilate added (μg.)	Chlorobenzilate found (μg.)
10	9·7
20	20·0
50	49
75	72·5
100	97
200	197

Fig. 2. Calibration curve for determination of chlorobenzilate.

The final form of the method is given below.

Reagents.

Ether : Fractionate technical grade over sodium.

Methyl alcohol : Fractionate B.P. grade after the addition of sodium.

2-Ethoxyethanol : Distil technical quality after the addition of sodium.

Carbon tetrachloride : Fractionate A.R. grade.

Nitration mixture : Add cautiously an equal volume of A.R. concentrated sulphuric acid to well stirred A.R. fuming nitric acid (S.G.1·5).

Stearic acid solution : Twice recrystallize stearic acid from ethyl alcohol and prepare a 0·5% solution in light petroleum B.P. 40-60°C.

Saturated sodium sulphate : Treat a saturated solution of A.R. sodium sulphate with gaseous sulphur dioxide to suppress mould growth.

Cotton wool : Extract with hot alcohol.

Methanolic potassium hydroxide, 5 per cent. : Prepare freshly in the cold and filter.

Stopcock lubricant : Mix bentonite with glycerol.

Procedure.

Extract a convenient number of disc samples 3 times with carbon tetrachloride in a Soxhlet extractor. Remove the extraction flask from the apparatus immediately before the fourth syphoning and add 2 ml. of the stearic acid solution together with a glass bead. Remove the solvents at 56°C. and 21

cm. pressure. Add 5 ml. of nitration mixture and then fit each flask with an air condenser. Partially immerse the flasks in a boiling water bath for 1 hour. (This operation should be performed in a fume cupboard with a good draught). Remove the flasks from the water-bath and cool for 5-10 minutes in ice-water. Add 50 ml. of saturated sodium sulphate solution and transfer the contents of the flask to a 125 ml. separating funnel with the aid of 70 ml. of ether and 25 ml. of saturated sodium sulphate. After 30 seconds vigorous shaking discard the lower aqueous layer and wash the solvent layer successively with 25 ml. and 10 ml. of 5% potassium hydroxide and 15 ml. saturated sodium sulphate. Run the ethereal layer slowly through a 15 mm. layer of anhydrous sodium sulphate held in a filter funnel by a small plug of cotton wool. Collect the filtrate in a B19 100 ml. round-bottomed flask, add a 5 mm. diameter glass bead, and evaporate to dryness in a water bath at 56°C. Dissolve the residue in 0·5 ml. 2-ethoxyethanol and add 10·0 ml. of 5% methanolic potassium hydroxide. Measure the absorption in a 1 cm. cell after 30 minutes, using a Unicam S.P. 600 spectrophotometer set at 538 mμ.

Application of the Method.

The method has been used to determine deposits of chlorobenzilate in experiments on the control of the Big Bud mite of the black currant ; attention was directed particularly to the protection of new buds developing in the leaf axils. Technical chlorobenzilate in a succinate wetter formulation was found to give inadequate wetting of the leaves, but this was overcome by the use of an experimental quaternary ammonium wetter, at 0·1 per cent., used with chlorobenzilate at 0·025, 0·05 and 0·10 per cent. concentrations.

Blackcurrant shoots, *var.* Davison's Eight, were dipped in the spray fluid and allowed to air-dry in the position naturally taken up on the plant ; developing buds with small pieces of stem and petiole tissue attached were then cut from the axils of the leaves. Leaf discs of 1.71 cm. diameter were also taken for examination, the samples for analysis consisting of 25 leaf discs or 100 buds. The results are shown below.

Chlorobenzilate in spray (per cent.)	Chlorobenzilate deposits (μg.) per sq. cm. of leaf	per bud
nil	nil	nil
0·025	1·2, 1·1	2·5, 2·4
0·05	2·3, 2·5	—
0·10	5·7, 6·7	—

The level of deposit from the 0·025 per cent. concentration is of the same order as that from spring washes of DDT, which is also used at a concentration of 0·025 per cent. Work on the determination of DDT and chlorobenzilate occurring together in spray deposits will be reported later.

Summary.

A method is described for the determination of chlorobenzilate in spray deposits.

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SPRAY APPLICATION PROBLEMS: XXXV. THE CONTROL OF LEAF SPOT DISEASE (*MYCOSPHAERELLA MUSICOLA*) ON LACATAN BANANAS. THE LEVELS AND DISTRIBUTION OF BORDEAUX MIXTURE DEPOSITS.

By H. G. H. KEARNS and J. T. MARTIN.

In the West Indies since 1945 the Gros Michel variety of banana has been extensively replaced by the Lacatan variety due to its resistance to Panama Disease (*Fusarium oxysporum cubense*). Unfortunately Lacatan is very subject to Leaf Spot Fungus which must be controlled to obtain profitable crops. The fungus infects the banana leaves by conidiospores and by ascospores; the variety Gros Michel is infected mostly by conidiospores whereas Lacatan is infected almost exclusively by ascospores. The accepted method of controlling Leaf Spot is by the application of copper fungicides, especially Bordeaux mixture, at intervals of 3 weeks. This aims at maintaining a cover of the fungicide on the leaves to render conidiospores non-viable, and so prevent infection of the vulnerable unfolding vertical funnel leaf (1). It was shown by Kearns and Naylor (2, 3) that the ascospore infection is controlled by the application of copper fungicides to the under-side only of the just unfolded first and second leaves. It was essential that the interval between spray applications should not exceed two weeks during the period of rapid growth and that the under-surfaces of the leaves should be completely covered by the spray deposit. A comprehensive series of experiments were carried out in the West Indies from 1952-55 to determine the levels and distribution of copper fungicides on banana leaves.

The spray target—the banana leaf.

The youngest leaf develops in the form of a vertical funnel (the " funnel leaf ", Plate VII, Fig. 1) which unfolds, with the under-side exposed, at the rate of several inches a day. Under the most favourable conditions it is full grown in 5-7 days, and immediately another funnel leaf develops. It is during the unfolding stage that the young leaf is most vulnerable to conidiospore infection and protection at this stage is essential if the disease is to be controlled. The freshly unfolded leaf is called the first leaf and the under-side is vulnerable to infection by ascospores generally on the terminal portion only, hence the commonly used description of " tip spotting."

The young banana leaf is extremely difficult to wet; rain and all normally formulated sprays run off in the form of round droplets. The small amount of fluid retained on the leaf by chance has a precarious hold and can readily be removed by shaking the leaf, leaving an entirely unwetted surface.

The undersides of the funnel leaf and the first leaf are the most difficult surfaces to wet, due to the presence of a delicate layer of wax-like material exuded by the leaf. If this layer is gently rubbed off, the exposed surface is readily wetted. As the leaf grows older it becomes more easily wetted, presumably due to a change in the wax on the under-side and to the accumulation of dust particles and saprophytic fungi on the upper surface.

The fully grown leaf is 6 or more feet long and $1\frac{1}{2}$-2 feet wide, and consists of a thick fleshy central rachis with veins arising from it on either side about $\frac{3}{8}$" apart. The rachis is deeply grooved on the upper surface and at the base ensheathes the stem to form a pocket; it acts as a channel down which rain and sprays flow into the pocket and overflow. The slightly raised veins on the upper-side of the leaf are more readily wetted than the intervenal tissue. If a leaf is carefully sprayed with a fungicide incapable of wetting the intervenal tissue, most of the veins will be covered along their length with a fine deposit. The fungicidal value of this venal deposit has not been investigated but it may be redistributed to the intervenal areas by dews which frequently cover the upper and under-sides of the leaves with small droplets of water. A copper fungicide applied to the under-sides of the first and second leaves (Plate VII, Fig. 2) acts as a protective spray and probably as an eradicant of infections by the just-germinated ascospore. Applications of copper fungicides to the third leaf failed to give a control of an infection. It was clear that the control of the disease could only be achieved by complete coverage of the under-sides of the two top leaves.

The spray coverage of the target.

Bordeaux mixture (0·2 per cent. Cu) consisting of 8 lb. copper sulphate, 10 lb. hydrated lime and 100 gallons water was used exclusively in Jamaica up to 1955 and in many of the other banana growing countries. It was applied at the rate of 80-200 gallons per acre, every effort being made to cover all the leaves. The top leaves vulnerable to infection, however, are nearly unwettable and therefore retained only a small amount of fungicide which was extremely badly distributed. Careful mist spraying gave a good distribution of small droplets but these were readily dislodged by leaf movement due to the wind, or by over-spraying which caused the droplets to coalesce and run-off, leaving the leaf surface completely unwetted. Occasionally the retention of droplets on a leaf may result from the evaporation of the water and consequent increase in concentration of the spray which enables it to wet the surface sufficiently to result in adhesion.

The nature of the infection by ascospores suggested that it was necessary to ensure uniform distribution of the fungicide on the under-side of the first open leaf; this was best obtained by using a wetter that ensured complete wetting and adequate retention. A number of wetters were examined and of those commercially available, sodium dinonyl sulphosuccinate and a non-ionic alkyl aryl polyether alcohol wetter were the most satisfactory. The succinate at concentrations of 0·0125-0·025 per cent. gave immediate wetting and spreading on the leaf surface, but as it was an ionic material it could not be used with Bordeaux mixture although it was entirely satisfactory with cuprous oxide, copper carbonate and copper oxychloride. The alkyl aryl polyether alcohol wetter, which was compatible with Bordeaux mixture, gave optimum wetting at 0·04 per cent. and a reasonably satisfactory wetting at 0·025 per cent., but at neither concentration did it provide the instantaneous and uniform wetting obtained with the succinate. When the Bordeaux mixture incorporating the non-ionic wetter dried out on the leaf parallel zones of high and low deposits due to streaming could be seen.

PLATE VII.

Leaf Spot Disease of Bananas.

Fig. 1. The vertical "funnel leaf" of banana which is subject to infection by conidiospores.

Fig. 2. The first and second leaves which must be sprayed on the underside with copper fungicides to prevent infection by ascospores. A young "funnel leaf" is developing between the leaves.

Spray deposits on the underside of the first leaf of Lacatan bananas.

Fig. 3. The round black spots are deposits of Bordeaux Mixture (0.2 per cent Cu.) when used without added wetter.

Fig. 4. Heavy intervenal deposits of Bordeaux Mixture (0.2 per cent Cu.) when non-ionic wetter added.

The Spray Treatments.

The 1955 experiment was devoted to a final examination of the value of Bordeaux mixture, based on experience gained in the earlier years. In all the tests reported, application was made to the under surface of the young unfolded leaf two to three days old. The Bordeaux mixture was prepared from good quality copper sulphate crystals (25 per cent. Cu) and hydrated lime. The ratio of four parts by weight of $CuSO_4$, $5H_20$ to five parts of hydrated lime was used throughout the trials. The lime mixture was stirred into the copper sulphate solution using 40 per cent. of the total volume of water required, and the final volume of the spray was then adjusted by adding water. If a wetter was used it was added before the final dilution. Two samples (I and II) of non-ionic alkyl aryl poleyther alcohol wetter were used in the trials.

The following points were examined :—

(i) The value of mist spraying as opposed to spraying to run-off with Bordeaux mixture of 0·2 per cent. copper without the addition of wetter.

(ii) The effect of the addition of different concentrations of non-ionic wetter to Bordeaux mixture of 0·2 per cent. copper.

(iii) The effect of different concentrations of copper when using a constant concentration of wetter in the spray suspension.

The following treatments were used :—

A.	0·2	per	cent.	Cu.	Mist application.								
B.	0·2	,,	,,	,,	Application to run-off.								
C.	0·2	,,	,,	,,	+ 0·03	per	cent.	wetter	I	to	full	coverage.	
D.	0·2	,,	,,	,,	+ 0·02	,,	,,	,,	I	,,	,,	,,	
E.	0·2	,,	,,	,,	+ 0·03	,,	,,	,,	II	,,	,,	,,	
F.	0·2	,,	,,	,,	+ 0·02	,,	,,	,,	II	,,	,,	,,	
G.	0·4	,,	,,	,,	+ 0·025	,,	,,	,,	I	,,	,,	,,	
H.	0·2	,,	,,	,,	+ 0·025	,,	,,	,,	I	,,	,,	,,	
I.	0·15	,,	,,	,,	+ 0·025	,,	,,	,,	I	,,	,,	,,	
J.	0·1	,,	,,	,,	+ 0·025	,,	,,	,,	I	,,	,,	,,	
K.	0·05	,,	,,	,,	+ 0·025	,,	,,	,,	I	,,	,,	,,	
L.	0·4	,,	,,	,,	+ 0·025	,,	,,	,,	II	,,	,,	,,	
M.	0·2	,,	,,	,,	+ 0·025	,,	,,	,,	II	,,	,,	,,	
N.	0·15	,,	,,	,,	+ 0·025	,,	,,	,,	II	,,	,,	,,	
O.	0·1	,,	,,	,,	+ 0·025	,,	,,	,,	II	,,	,,	,,	
P.	0·05	,,	,,	,,	+ 0·025	,,	,,	,,	II	,,	,,	,,	

A number of trials were made with the various types of manually and power operated spraying machines used on commercial plantations. A technique was evolved so that the spray deposits obtained with commercial machines could be simulated with a small pneumatic sprayer fitted with a ceramic fan-spray nozzle. Tests showed that the performance of hydraulic nozzles had little influence on the nature of the deposit compared with the effect of the physical properties of the spray fluid.

The preparation of samples.

The first leaf, vulnerable to infection by ascospores, was used for assays of spray deposits. Its position varied from the nearly vertical to the nearly horizontal, according to the age of the trees and layout of the plantation; the taller and denser the trees the more vertical the leaf.

The mist spray deposit using Bordeaux mixture alone (Treatment A) was obtained as the result of several attempts to obtain a uniform distribution of small droplets on a vertical leaf. The deposit showed a uniformity rarely achieved with commercial spraying. Treatment B, on the under-side of a vertical leaf, provided a fair indication of the distribution obtained with a drenching application of Bordeaux mixture without wetter. For the remainder of the treatments, the first leaves, within 2-3 days after becoming fully open, were cut down and sprayed, under-surface uppermost in a flat position on the ground. This method was found to give deposits similar to those obtained when spraying leaves left on the trees. Care was taken in handling the leaves to avoid damage to the wax bloom. It was preferable to obtain only sufficient leaves for 2-3 hours work; before use they were stacked in a vertical position with the base of the rachis in water. Most of the leaves were 5-8 ft. long and 1½-2 ft. wide. The spray was applied at the rate of one-fifth of a pint per leaf, which completely flooded the surface. The leaf was then carefully lifted and fixed in a vertical position so that all the excess spray fluid drained off.

The rate of application used was equivalent to 40 gal. of spray applied to the under-sides of the three top leaves of an acre of mature bananas, which is six times the volume the leaves can retain.

When dry the leaf was placed on a table and 10 samples each 10″ × 5″ were cut with the aid of a raised template. The ten samples for each spray treatment (see Table I) were taken in the same sequence from one leaf. The sample identified as position (a) was at the terminal position of the right-hand under-side of the leaf and (e) at the basal position; similarly (f) and (j) respectively occupied the same positions on the lefthand side. The outer edge of the leaf was discarded to avoid any deposit of spray that might have crept during spraying on to the top surface. The leaf samples were placed between two pieces of thin paper and were slowly dried in an electrically heated oven, care being taken to avoid overheating to make them brittle. They were then transported by air to Long Ashton.

The Analysis of Samples.

The leaf samples from the 1952-54 experiments were analysed by ashing, or where estimates of deposits on the upper and lower surface of the leaf were required, by washing each surface separately with dilute nitric acid, followed by colour formation with sodium diethyldithiocarbamate. The laborious nature of these operations led to the development of the rapid method using bis-*cyclo*hexanone oxalyldihydrazone (4, see also p. 125).

On receipt at Long Ashton, the areas of the dried leaf sections were determined so that the results of analysis could be calculated per unit area of the fresh leaf.

The levels of deposits. The average amount of copper deposited on each leaf section was determined as follows: Ten discs, each 3 sq. cm. in area, were punched from each section and washed with 10 ml. of *N*. sulphuric acid with the addition of a wetter. The acid solution was transferred to a 100 ml. graduated flask, 10 ml. of 10 per cent. ammonium citrate were added, the solution was made alkaline to neutral red with 2*N* ammonia and made up to volume. To 10 ml. were added 10 ml. of a 0·1 per cent. solution of the

dihydrazone reagent in 50 per cent. ethyl alcohol, and the optical density was measured, after 30 minutes, in the Unicam SP 600 spectrophotometer. The results are given in Table I.

TABLE I.

MEAN DEPOSITS, AS μg. CU/SQ. CM., ON BANANA LEAF SAMPLES.

Treatment	Position of sample in leaf										Average over leaf
	a	b	c	d	e	f	g	h	i	j	
A	1·9	2·7	1·6	1·4	1·4	1·1	1·6	1·7	1·0	2·0	1·6
B	4·3	1·4	1·1	1·4	8·2	1·0	0·7	3·8	2·7	1·4	2·6
C	7·8	6·3	7·2	7·5	8·7	7·7	7·2	7·7	8·8	7·5	7·6
D	8·7	7·4	8·3	9·2	9·2	7·6	8·3	6·9	5·8	3·1	7·5
E	8·6	9·0	8·9	8·8	8·9	8·3	8·3	8·0	10·5	9·8	8·9
F	6·1	7·1	6·9	9·6	11·5	7·2	6·8	8·4	9·3	10·6	8·4
G	18·8	19·0	21·9	25·9	36·7	17·9	19·5	21·4	16·5	17·9	21·5
H	5·0	9·1	8·1	9·3	9·9	8·2	6·1	7·2	7·2	8·6	7·9
I	4·3	5·1	5·2	5·5	6·8	6·0	7·1	7·3	6·6	5·8	6·0
J	3·9	4·1	4·8	3·8	6·2	3·4	3·5	3·8	4·4	4·1	4·2
K	2·0	2·2	2·3	2·4	2·3	2·3	2·5	2·0	2·5	1·2	2·2
L	16·3	20·0	18·4	18·2	16·5	14·7	21·7	22·8	18·6	18·2	18·6
M	5·9	6·6	7·8	8·9	9·0	4·8	5·8	8·2	10·4	12·5	8·0
N	4·8	3·7	4·7	6·3	7·1	3·7	4·4	5·3	6·5	7·4	5·4
O	5·1	5·8	4·0	3·9	4·4	4·2	6·2	2·6	4·6	6·0	4·7
P	2·1	3·0	3·2	2·2	2·1	2·2	1·0	1·4	2·3	1·7	2·1

Tests using the standard ashing-dithiocarbamate method were carried out on the leaf discs after treatment as above to determine the amount of copper left undetected by the dihydrazone method. The maximum amount of residual copper found was 0·5 μg/sq. cm.; this value includes the copper occurring naturally in the leaves. Other comparative analyses showed satisfactory correlation, allowing for the sampling errors in taking discs, between the levels of deposits recorded by the dihydrazone and the standard ashing-dithiocarbamate methods.

The distribution of deposits. The distribution of the deposit over each section of leaf was determined by the analysis of individual discs, each of 3 sq. cm. area. Ten discs were taken from each leaf section at random.

The method used was described in an earlier report (4). The percentage coefficient of variation of deposit (V) was calculated from the analytical data recorded. The results for each leaf section, for selected treatments, are given in Table II.

TABLE II.

PERCENTAGE COEFFICIENT OF VARIATION OF DISTRIBUTION OF COPPER DEPOSITS ON BANANA LEAF SAMPLES.

Treatment	Position of sample in leaf										Average over leaf
	a	b	c	d	e	f	g	h	i	j	
A	92	18	45	48	23	40	22	37	34	49	40·8
B	39	38	26	42	57	54	49	84	27	54	47·0
C	8	19	23	17	14	16	23	26	17	18	18·1
E	20	19	31	16	20	21	16	9	20	16	18·8
O	25	30	28	14	8	14	23	17	16	17	19·2
P	11	18	25	24	11	37	27	15	19	33	22·0

Imprints of the deposits from all treatments were made for microscopic examination. An area of leaf surface was covered with a thin layer of a dilute solution of industrial nitrocellulose in ethyl acetate, confined within a shallow glass ring. On evaporation of the solvent, a transparent film of nitrocellulose bearing the deposit was obtained. A small piece of the film was treated with sodium diethyldithiocarbamate and mounted on a microscope slide with glycerin phenol. Photomicrographs of the deposits obtained from treatments with Bordeaux mixture alone and with Bordeaux mixture incorporating a non-ionic wetter are shown in Plate VII, Figs. 3 and 4. The heavier deposit resulting from the incorporation of wetter in the spray fluid is clearly seen.

Discussion.

Bordeaux mixture, containing 0·2 per cent. Cu, carefully applied as a fine mist of small droplets (Treatment A) gave deposits of the same order as those from Bordeaux mixture of the same strength applied in drenching amounts (Treatment B) and markedly lower than those from full-coverage sprays of Bordeaux mixture incorporating a non-ionic wetter (Treatments C-F). The Bordeaux mixture applied alone in drenching amounts gave an average deposit on the under surface of the leaf of 2·6 μg/sq. cm. with considerable variations in the levels of deposit on different portions of the leaf. The addition of 0·025 per cent. of wetter to the spray fluid (Treatment H) increased the average deposit to 7·9 μg Cu/sq. cm. with greatly improved uniformity of distribution. It should be noted that the distribution of deposit from Treatment B (Bordeaux mixture without a wetter) was strikingly superior to that usually obtained with normal plantation spraying.

In Treatments K and P, using Bordeaux mixtures at 0·05 per cent. Cu with 0·025 per cent. of wetter, the average deposits of 2.2 and 2·1 μg Cu/sq. cm. were approximately as good as those obtained with the mist or drenching applications of Bordeaux mixture alone at 0·2 per cent. Cu. The incorporation of the wetter also improved the distribution of the deposit.

Trials with Bordeaux mixtures of decreasing copper concentrations, used with 0·025 per cent. of wetter, showed approximately proportional reductions in the levels of deposits. There were no significant differences in the results obtained with the two samples of wetter.

The investigations have clearly shown the value of the incorporation of a suitable wetter in improving the levels and distribution of Bordeaux mixture deposits on the under surfaces of leaves of the Lacatan variety of Banana. The need to spray only the young unfolded leaves to control the ascospore infection has also been demonstrated. These findings have resulted in greatly improved efficiency in spraying for the control of the Leaf Spot Disease.

Summary.

(1) A description is given of the spraying requirements for the control of the ascospore infections of the Leaf Spot Disease of the Lacatan variety of banana by means of Bordeaux mixture.

(2) The levels and distribution of deposits of Bordeaux mixture used with and without wetters were determined.

(3) The addition to Bordeaux mixtures of a non-ionic wetter ensured satisfactory deposition and a high uniformity of distribution of the fungicide.
(4) The retention of Bordeaux mixture, used in conjunction with the wetter, increased proportionally with the concentration of the fungicide.

Acknowledgments.

Thanks are due to Mr. A. C. Naylor, Department of Agriculture, Jamaica, for his assistance in the preparation of the leaf samples, and to Mr. R. F. Batt and Miss P. M. Jackson for the analyses made at Long Ashton.

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SPRAY APPLICATION PROBLEMS: XXXVI. BENZENE, TOLUENE AND NAPHTHA FORMULATIONS OF SPRING WASHES.

By H. R. MAPOTHER and R. F. BATT.

Introduction.

Following their earlier work on the control of the leaf-curling plum aphid by a DDT emulsion applied at bud burst, Kearns and Morgan (1) described the preparation of an emulsion of DDT-gamma-BHC of high wetting properties for use as a substitute for winter washes. In more recent work (2) chlorbenside has been incorporated with the DDT and BHC to counteract the build-up of the Fruit Tree Red Spider mite.

Kearns and Morgan used commercial benzene in the formulation of the spray materials for the experimental work. This solvent has some disadvantages : it has a low flash point and its vapour, which is known to be toxic to humans, is objectionable when preparing the emulsions in enclosed spaces. Trials were therefore carried out in 1956 to ascertain to what extent toluene or solvent naphtha could be used instead of benzene. The efficiencies of emulsions prepared using the three solvents have been assessed, in this work, from the deposition of DDT and of DDT-chlorbenside on apple leaves and flower buds.

Experimental.

Preparation of the spray materials.

The emulsion concentrates were prepared in a Pentacreme machine and were based on the following formulation :

DDT emulsion.	*DDT-chlorbenside emulsion.*
1 lb. DDT.	1 lb. DDT, 0·8 lb. chlorbenside.
3 pints of solvent.	3 pints of solvent.
3 pints of 20 per cent. sulphite lye.	3 pints of 20 per cent. sulphite lye.
To 400 gallons	To 400 gallons

Solvent Specifications

Toluene. Specific gravity between 0·860 and 0·875 at 15·5°C.
Distillation range : Not more than 5 per cent. at 105°C.
Not less than 90 per cent. at 120°C.
Residue on evaporation : Not more than 5 mg./100 ml.

Naphtha. Specific gravity not less than 0·850 at 15·5°C.
Distillation range : Not more than 5 per cent. at 125°C.
Not less than 90 per cent. at 160°C.
Residue on evaporation : Not more than 10 mg./100 ml.

A dry form of sulphite lye was used, 10 oz. being equivalent to 1 pint of lye of specific gravity 1·3. Dinonyl sodium sulphosuccinate, as a 50 per cent. solution in acetone, was incorporated at 0·02 per cent.

Dipping and spraying trials.

Flower clusters of Cox's Orange Pippin, taken from the trees in the first week in May at pink-bud, were dipped in the diluted DDT spray materials. Four replicates were used for each treatment. Leaf discs and flower buds were air-dried and powdered for analysis by the method of Martin and Batt (3) and the total DDT, as surface or absorbed deposit, was recorded. The results are given in Table I.

TABLE I.

DDT DEPOSITS AFTER DIPPING IN BENZENE, TOLUENE AND NAPHTHA EMULSIONS

	Leaves		*Flower buds.*	
Solvent	Area (*sq. cm.*)	*DDT/sq. cm.* (μg.)	*No.*	*DDT/bud* (μg.)
Benzene ..	65	1·6	22	8·5
	64	1·5	22	7·7
	65	1·4	25	8·0
	78	0·9	24	9·5
Toluene ..	77	1·6	28	10·4
	59	1·4	24	12·2
	63	1·7	25	13·0
	49	1·9	19	12·4
Naphtha ..	72	1·3	24	10·5
	68	1·4	24	11·2
	79	1·1	26	11·4
	55	1·4	28	9·7

The deposits of DDT from the toluene emulsion are slightly higher on the leaves (mean value 1·6 μg./sq. cm.) than those from the benzene and naphtha emulsions (1·3 μg./sq. cm.) ; this is also shown in the deposits on the flower buds, the mean value for toluene being 12·0 μg./bud compared with 8·4 and 10·7 μg./bud for benzene and naphtha respectively.

Spraying trials in the field were carried out during August and September 1956 using the benzene, toluene and naphtha DDT emulsions, and the benzene and naphtha DDT-chlorbenside emulsions. Application was made to pyramid Cox trees by means of a small power-driven machine. Leaves were taken one hour after spraying, after the spray films had dried, and at weekly intervals. Surface and absorbed DDT and chlorbenside were determined by the method of Martin and Batt (4). The results are given in Table II.

TABLE II.

DDT AND CHLORBENSIDE DEPOSITS AFTER SPRAYING WITH BENZENE, TOLUENE AND NAPHTHA EMULSIONS.

(μg. per sq. cm.)

		Initial deposit	*After 7 days*	*After 14 days*
DDT emulsion				
Benzene	Surface DDT	1·1	0·3	0·1
	Absorbed DDT	0·1	0·1	0·2
Toluene	Surface DDT	1·0	0·3	0·1
	Absorbed DDT	0·2	0·1	0·1
Naphtha	Surface DDT	1·0	0·4	0·2
	Absorbed DDT	0·1	0·1	0·1
DDT-chlorbenside emulsion				
Benzene	Surface DDT	0·9	0·5	0·2
	Absorbed DDT	0·0	0·1	0·1
	Surface chlorbenside	0·5	0·2	0·1
	Absorbed chlorbenside	0·2	0·2	0·2
Naphtha	Surface DDT	0·9	0·4	0·2
	Absorbed DDT	0·0	0·1	0·1
	Surface chlorbenside	0·5	0·1	0·1
	Absorbed chlorbenside	0·2	0·2	0·2

Some shoots, about 15 in. long, were dipped in the DDT emulsions without removing them from the trees. The results of the analysis of the leaves are given below as μg.DDT/sq. cm.

Solvent		*Initial deposit*	*After 28 days*
Benzene	Surface DDT	1·7	0·2
	Absorbed DDT	0·3	0·2
Toluene	Surface DDT	2·4	0·2
	Absorbed DDT	0·2	0·2
Naphtha	Surface DDT	1·4	0·2
	Absorbed DDT	0·2	0·1

The rainfall in the first week after spraying amounted to 5·76 in. and in the second week to 1·91 in. The total rainfall during the month following the dipping tests was 8·29 in.

There were no significant differences in the deposits on the leaves obtained by spray application of the three solvent formulations, but the deposits obtained by dipping shoots on the trees were markedly higher than those obtained by spraying. In the dipping tests, the toluene preparation again gave the highest deposit.

Another experiment was carried out to investigate the discrepancy between the levels of deposits resulting from spraying and dipping shoots on the trees. Leaves taken from M.II rootstocks were supported and sprayed individually on both sides to run-off; other leaves were dipped in the spray fluid. After allowing the leaves to dry in an upright position, analysis showed little difference in the deposits of DDT retained (sprayed leaves : surface 1·6, absorbed 0·1 μg./sq. cm.; dipped leaves : surface 1·4, absorbed; 0·1 μg./sq. cm.). It would, therefore, seem that the difference observed in the trials was due to incomplete coverage in field spraying.

A disturbing feature of the field trials was the rapid loss of surface deposits of DDT from the leaves, particularly during the first week, when a rainfall of 5·76 in. was recorded. To examine this point further, shoots of M.II rootstocks were dipped in the DDT emulsion and allowed to dry in the laboratory. They were then subjected to a continuous water spray from four $\frac{1}{4}$ in. nozzles with 2-slot swirl plates and 3/64 in. disc apertures. The initial deposit of DDT was 1·0 μg./sq. cm. : after 13 hours of washing the deposit had fallen to 0.75 μg./sq. cm.; a negligible reduction in comparison with the loss found after heavy rainfall in the field. It is possible that the conditions under which spray films dry may influence their retention by leaves, and it is proposed to investigate this matter more fully.

Summary.

Experiments to determine the level of DDT and chlorbenside deposits resulting from the application of benzene, toluene and solvent naphtha emulsions are described. No reduction in deposit followed the substitution of toluene or solvent naphtha for benzene in the preparation of the emulsion.

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SPRAY APPLICATION PROBLEMS: XXXVII. A DISC PUNCH FOR SAMPLING LEAVES FOR THE ASSAY OF SPRAY DEPOSITS.

By H. G. H. KEARNS and N. G. MORGAN.

Chemical micro-assays of deposits of several insecticides and fungicides are now of such accuracy that it is possible to take relatively small samples. This greatly facilitates the determination of variations in levels and distribution on such surfaces as leaves and thereby greatly aids the assessment of the performance of spray materials and of spray machinery. A rapid means of obtaining samples of known and equal superficial area is a pre-requisite for these assays. Morgan (1) in 1954 designed a pistol-type leaf sampler that cut discs of 20 mm. diameter and deposited them in a glass container. This type of sampler has the advantage of rapid sampling and avoids the packing of discs tightly on top of each other, or upon any portion of the sampler, but it is somewhat costly to manufacture except in large numbers. In lots of twelve the cost would be of the order of £8 each.

Demand for the sampler has led to the design of a simple and cheap model which has the advantage that the punch can be readily removed and replaced when it becomes blunt or when another size is required. Disc samples of two sizes, namely one half square centimetre and one square centimetre, have been selected as the most suitable sizes on the scores of sampling technique and of handling in the laboratory.

Specification.

The tool (Plate VIII) consists of a pair of pliers with long jaws, on one of which an anvil, and in the other a hollow punch, is fitted. The jaws are placed on either side of the leaf and the pressure applied cuts the disc, which slides into the hollow punch. Several discs may be cut at one time and removed by pushing out with a probe of 3 mm. diameter.

The pliers are made from a pressing of special steel, plated after manufacture to prevent rust. The jaws, after compression on a leaf, are opened by a spring to give a gap of about 14·5 mm. ($\frac{9}{16}$″). A tapered bush is welded into the distal end of each jaw, the bores of the bushes being axially in line ; into one the punch is fitted and into the other the anvil. The movement and proportions of the punch and anvil are so arranged that an even cut of the sample is assured and therefore a truly circular disc is formed.

The design and dimensions of the punch and anvil are shown in Fig. 1. The punch may be made of turning-quality brass, monel metal, or free-cutting stainless steel. A bore of 11·2 mm. ($\frac{7}{16}$″) punches a round disc of 1·13 cm. diameter (area 1 sq. cm.), and an 8 mm. ($\frac{5}{16}$″) bore punches a disc of 0·8 cm. diameter (area 0·5 sq. cm.). The diameter of the sample varies slightly according to the structure and thickness of the plant tissue ; the bores quoted above are the best compromise for extreme types of tissue. The variations are so slight that they are of little significance in a chemical assay. The punch is readily sharpened by removing, mounting in a lathe and turning externally to give a 20° taper : a very sharp edge is not necessary. The anvil is a brass

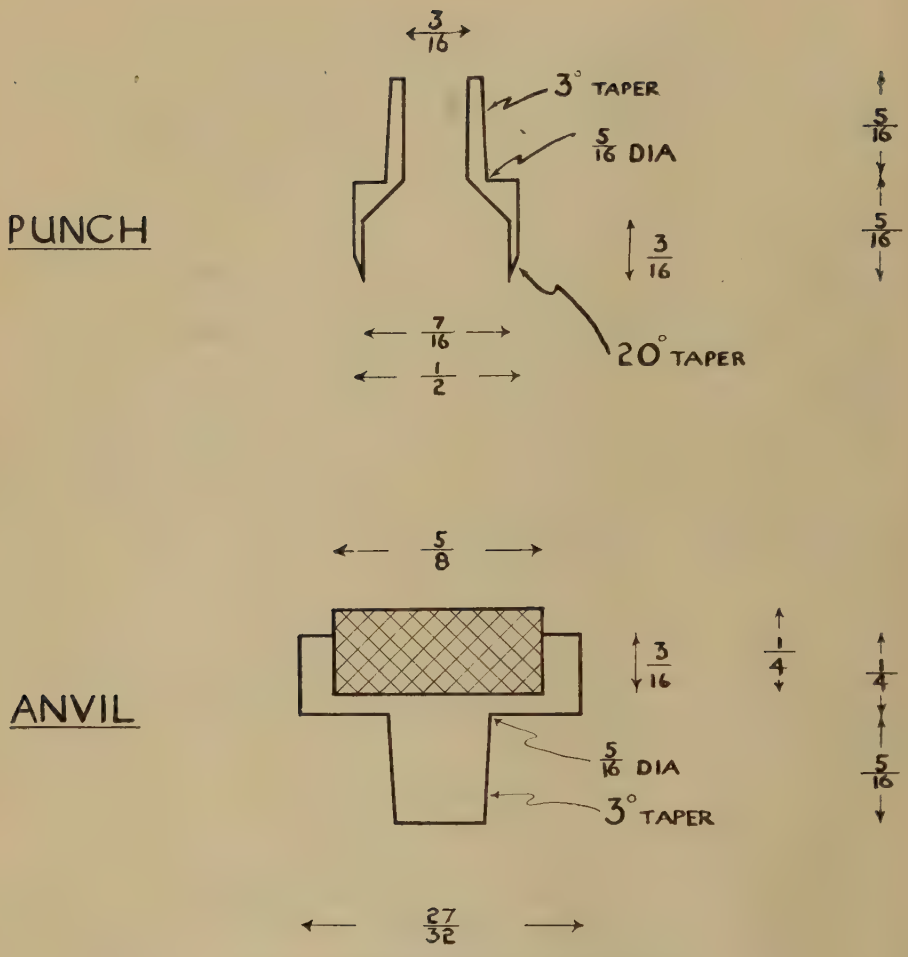

Fig. 1. Dimensions of punch and anvil in inches.

platform with a circular recess bored to 16 mm. ($\frac{5}{8}$″) diameter × 5 mm. ($\frac{3}{16}$″) deep; into this a rubber or polythene disc 17 mm. × 6·5 mm. ($\frac{2}{3}\frac{1}{2}$″ × $\frac{1}{4}$″) is a push fit. The resilient nature of the disc is an important feature, as it contributes to the clean punching of discs and prevents rapid blunting of the punch. The disc can easily be replaced when the surface is damaged by repeated cutting on the same surface. If there is a risk of transference of a spray deposit from the leaf to the rubber or polythene disc, a thin layer of a neutral material may be placed as a barrier between the anvil and leaf; leaf sample and neutral material are then assayed as the sample.

The length of the punch pliers is 8″ and the total weight 7 oz. The total cost, with spare anvils and anvil discs, is about £1.

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PLATE VIII.

The disc punch in operation.

SPRAY APPLICATION PROBLEMS: XXXVIII. A CENTRIFUGAL SPRAY PUMP. (With an 80 c.c. 2-stroke engine)

By H. G. H. KEARNS and N. G. MORGAN.

The design, performance and maintenance of light-weight 2-stroke powered sprayers have been described (1). It was shown that a 34 c.c. engine, driving a gear pump, gave a throughput of $7\frac{3}{4}$ pints per minute at a flow pressure of 75 lb. p.s.i., with a maximum performance of $3\frac{3}{4}$ pints at 125 lb. p.s.i. ; an engine of 70-80 c.c. capacity, driving a larger gear pump, gave a throughput of 19 pints per minute at 75 lb. p.s.i., with a maximum of 14 pints at 150 lb. p.s.i. The performance of these machines under various conditions in England and in the tropics has shown that the 70-80 c.c. machine has a wide range of uses for experimental and routine spraying ; it has been preferred because of the greater reliability obtainable at small additional cost.

An important simplification of the design has been made possible by the commercial production of a small reliable centrifugal pump capable of maintaining a flow pressure of 75 lb. p.s.i. Lubrication of the pump is unnecessary ; the need for a vee belt drive assembly is avoided ; the pump is less liable to damage by abrasion than the gear pump ; and a relief valve need not be fitted. These features render the spray machine well suited to a wide range of uses by unskilled labour.

Specification.

The Centrifugal Pump (Plate X).

The pump consists of five main parts : a body casting ; an impeller ; a pressure plate ; a cover plate casting, incorporating a suction inlet and a delivery outlet ; and a drive-shaft seal assembly. The only moving part is the impeller, rotating in a cavity formed by the assembly of the body casting and pressure plate.

The pump body (Fig. 4) is bolted through its spigot flange at the back to the crankcase of the engine. The impeller (Fig. 3) is attached by a key and stainless steel set-screws to the engine crankshaft, which extends through a central aperture in the pump body. A water-tight seal, fitted into the pump body around the crankshaft, consists of a spring-loaded carbon ring and plastic sealing washer. Between the engine crankcase and the pump body a drain hole is provided in case the seal should fail. Leakage of liquid from this hole is therefore a guide to the condition of the seal.

The impeller is a Pelton wheel of the multi-tooth regenerative pressure type ; it rotates in a cavity formed by the body casting and the removable pressure plate (Fig. 2). The cover plate casting (Fig. 1) incorporates a suction and delivery chamber, separated from each other by bridge pieces. The fluid passes from the suction chamber through the inlet portway of the pressure plate and is taken up by the rapidly rotating impeller and ejected through the outlet port into the delivery chamber of the cover plate casting. The sides of the impeller are a close fit to the walls of the impeller cavity and the high speed is sufficient to compensate for leakage between the two

chambers. Priming and draining plugs are fitted to the top and bottom of the cover plate. The pump body and cover plate are cast in good quality bronze, the impeller and pressure plate are of hard corrosion-resistant bronze alloy, and the engine crankshaft of non-corrodible steel. The pump is therefore suitable for all normal spray materials. The suction and delivery ways are threaded or tapped 1″ B.S.P. : this dimension allows a wide range of duties if suitable adaptors are used.

Assembly and Pump Fittings (Plate IX).

The pump and engine assembly is fitted into a tubular frame, designed for protection and portability. The engine and pump are bolted to two cross members of the frame so that removal can be carried out by unscrewing four nuts. The suction inlet, when used for spray work, is fitted with a 1″ B.S.P. × ¾″ B.S.P.M. adaptor to which an 8-12 ft. length of ½″ bore suction hose is fitted by means of a cap lining and wormclip ; the hose is fitted at the other end with an easily cleaned tubular filter as described for the gear pumps (1). It is important that an efficient filter be used to prevent the entry of large particles of abrasive matter into the impeller cavity.

The delivery is fitted with a 1″ B.S.P. × ¼″ B.S.P.M. adaptor of 60° internal taper so that a ¼″ B.S.P. hose nut with a taper-ended hosetail can be used to give a metal-to-metal union and thereby avoid the use of washers. If required a ¼″ B.S.P. relief valve assembly can be fitted to the delivery for special duties. In this event the overflow from the valve is delivered back to the suction chamber or to a spray tank by means of a hose : in the former case a water-tight connection can be made to the priming plug entry.

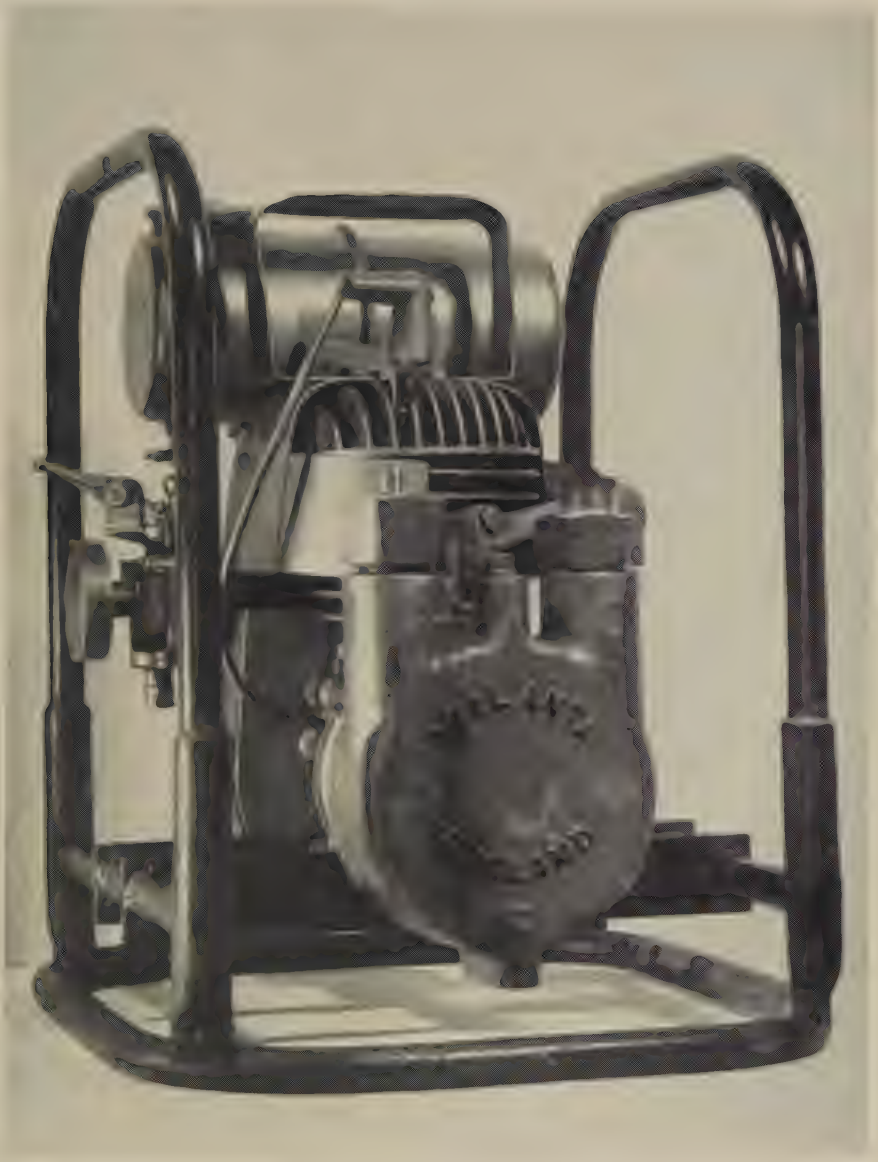
The weight of the engine, pump and tubular chassis is 45 lb.

Performance.

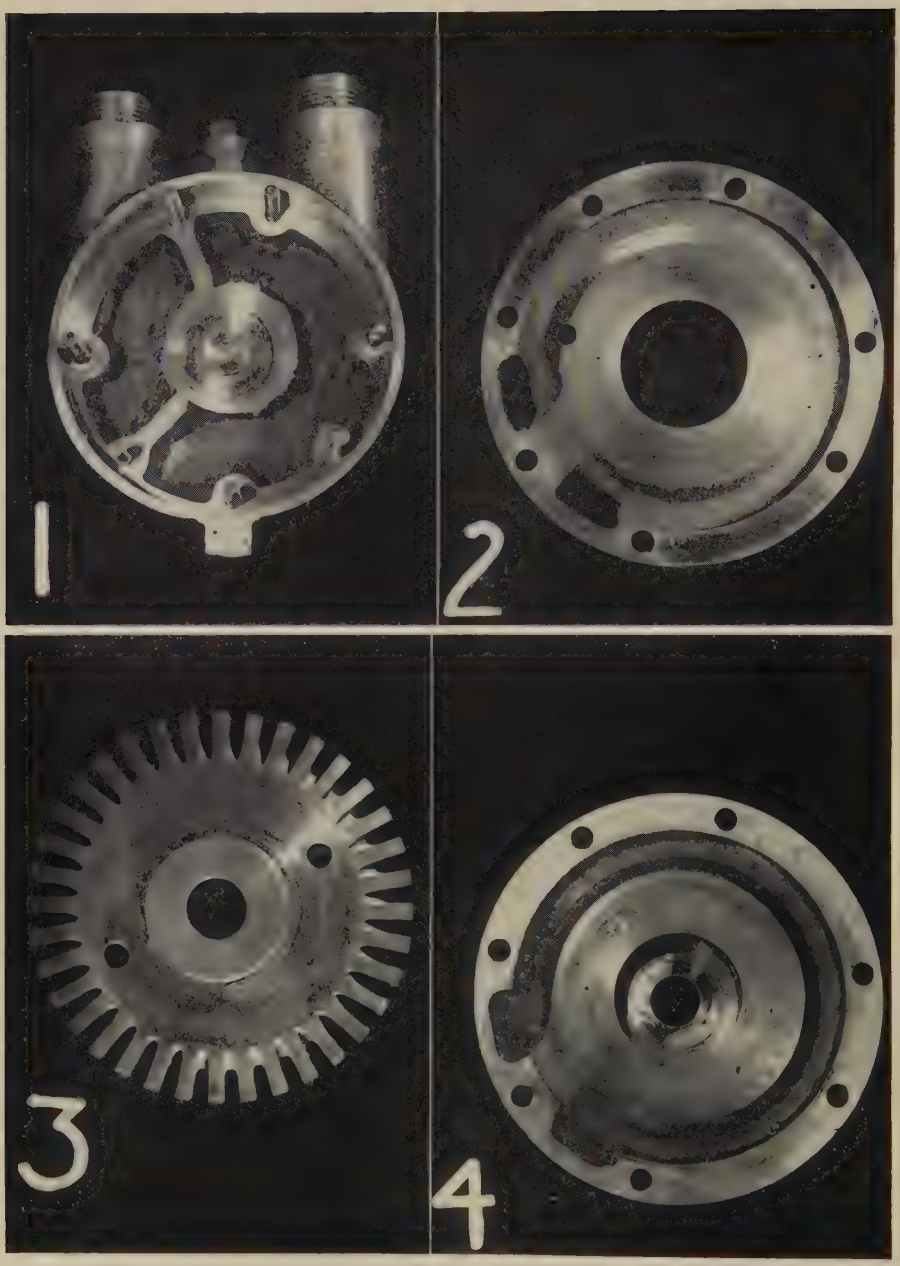
The normal speed of the engine, and therefore of the impeller, is 3,200-3,600 r.p.m. The maximum volume of the throughput within the above speed range is determined by the flow pressure and by the bore of the suction hose. The following are average performances tested under standardized conditions, using 1″ and ½″ bore suction hoses and 75 ft. of ½″ bore delivery hose.

Flow pressure	*Bore of suction hose*	
(lb. p.s.i.)	½″	1″
	Throughput (pints per min.)	
Free flow	29	46
20	29	44
30	29	41
40	29	39
50	28	36
60	27	34
70	25	31
75	24	30
80	22	28
90	19	24
100	16	20
>100	variable according to adjustment of pressure plate.	

PLATE IX.



General assembly of engine and pump in tubular chassis. Suction is indicated by arrow on casting. Delivery way is fitted with $\frac{1}{4}''$ B.S.P.M. hose adaptor.



The centrifugal pump. (1) The pump body, with small suction cavity on left and larger delivery cavity on right. (2) The pressure plate, showing suction and delivery ports. (3) The impeller. (4) The pump body, with recess for seal gland.

The maximum pressure developed varies with individual pumps because of slight variation in the clearance of the impeller from the walls of the impeller cavity. The maximum performance is 150 lb. p.s.i. and the average 120 lb. p.s.i. The above figures show that for maximum throughputs a 1″ bore suction hose is necessary. For lance spraying, a nozzle throughput of 4-8 pints per minute at a flow pressure of 75 lb. p.s.i. is often all that is required; hence a surplus capacity of two gallons is available when using a ½″ bore suction hose. The energy from this surplus capacity can be of considerable value, as it permits the use of very long lightweight ¼″ bore hoses, with which a large area can be sprayed without moving the pump, which is placed near to a convenient water supply. The throughputs and flow pressures of varying lengths of ¼″ bore hose are shown below for lance pressures adjusted to 75 or 30 lb. p.s.i. The hose length is given in increments of 75 ft., each length being connected by a hose coupling of 3/16″ bore :—

Length of Hose (ft.)	*Pressure at Pump* (lb. p.s.i.)	*Pressure at Lance* (lb. p.s.i.)	*Throughput* (pints)
75	130	75	9
75	125	30	10¼
150	125	75	7
150	120	30	10
225	125	75	6¼
225	120	30	9
300	135	75	6¼
300	125	30	7¾
375	135	75	5¼
375	125	30	6½
450	135	75	4¾
450	125	30	6½

The differences in pressure at the pump during this test were mostly due to the difficulty of maintaining a constant speed of the engine; the figures quoted are the average results of several tests. The two flow pressures of 75 and 30 lb. per sq. in. at the lance were selected as the working pressures recommended for a ¼″ B.S.P. swirl nozzle and a flat-spray ceramic nozzle, respectively (2).

Operation.

The operation of the engine has been described previously (1). The pump should not be allowed to run dry, as the shaft seal may be damaged, thus preventing the formation of a vacuum in the suction chamber. The best procedure is to remove the suction hose and fill up the pump with water or the spray liquid; then replace the hose, taking care that the hose coupling is screwed up tight, with a washer in the cap; then put the suction filter into the container of spray. Attach the delivery hose to the ¼″ B.S.P.M. adaptor, open the lance tap to allow the escape of air, and then start up the engine, which may be run at nearly full throttle within a few seconds. Once the pump is started it will not require any further priming so long as the end of the suction hose is covered with fluid. Removal of the suction hose from the spray while the engine is working with the lance in operation may make it necessary to reprime the pump.

For routine spraying a relief valve is an unnecessary complication and the general performance of the pump will be as shown above. If the lower nozzle throughputs are required, the flow pressures will be greater than shown, but this will not result in an unsatisfactory spray pattern, as the performance of the nozzle is satisfactory at the maximum pressure of the pump.

If, however, a particular flow pressure is required at the lance, it is necessary to fit a relief valve to the delivery of the pump. The adjustment is made by fitting a test gauge assembly to the base of the lance, then attaching the selected length of hose and opening the lance tap. The valve on the pump is adjusted to the required pressure.

Maintenance.

The only lubrication required is the addition of oil to the petrol of the engine, at the rate of ½ pint of a high grade oil of S.A.E. 30 to each gallon of petrol. The engine should be stopped by turning off the flow of petrol to the carburetter; this procedure empties the float-chamber and avoids oil accumulation, thus making re-starting easier.

After spraying, the pump should be washed through with clean water, and in frosty weather it should be completely drained before storing. If the pump refuses to operate or if delivery becomes erratic, it is usually the sign of an air leak due either to a faulty suction hose washer or to the failure of the seal on the shaft. The seal is located on the engine shaft in the pump body spigot and is easily fitted after removal of the cover plate and the impeller.

A persistent fall below normal pressure usually indicates that undue wear has occurred between the impeller and the walls of the impeller cavity. This may be remedied by machining the face of the pressure plate and sometimes of the body casting as well; this adjustment requires skilled attention to obtain the correct clearances.

Summary.

(1) A specification is given of a simple lightweight spray machine, consisting of a centrifugal pump mounted directly on the shaft of an 80 c.c. 2-stroke engine.

(2) The engine and pump are assembled in a simple tubular chassis, and have a total weight of 45 lb.

(3) The machine is well suited for unskilled users, as operation and maintenance are simple.

Acknowledgments.

The assistance of Mr. D. E. Aliband and Mr. J. H. Russell is gratefully acknowledged.

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SPRAY APPLICATION PROBLEMS: XXXIX. A GENERAL PURPOSE LANCE FOR USE WITH POWER SPRAY MACHINERY ON TROPICAL CROPS.

By H. G. H. KEARNS and N. G. MORGAN.

A simple type of spray lance for use with power-operated machinery for the application of sprays by native labour has many uses in the tropics. The lance must be suitable for a wide range of crops; it must be of robust design and contain a minimum number of components. All parts requiring regular cleaning must be capable of being taken apart and assembled without the use of spanners. A large filter is essential to prevent blockages of the nozzle by the use of dirty water, Bordeaux mixture, etc. A lance has been designed to suit these requirements.

Specification.

The lance weighs $3\frac{1}{2}$ lb.; it comprises an aluminium tube, a nozzle, a filter and a tap with a male hose-coupling thread (Plate XI); a length of 5ft. is satisfactory for spraying coffee, citrus, young banana plants, *Abaca* hemp, etc. A convenient lance tube is an aluminium alloy of $\frac{1}{1}\frac{3}{6}''$ O.D. diameter with $\frac{1}{2}''$ bore, lined with polyvinyl chloride to give a final bore of $\frac{7}{1}\frac{}{6}''$ (Fig. 2); the lining prevents corrosion of the alloy, especially by copper fungicides. Each end of the lance is threaded $\frac{1}{2}''$ B.S.P.M. $\times$ $\frac{5}{8}''$; the nozzle end is fitted with a $\frac{1}{2}''$ W. (·919 A.F.) hexagonal brass adaptor bored $\frac{9}{1}\frac{}{6}''$ and threaded $\frac{1}{2}''$ B.S.P.M. $\times$ $\frac{1}{2}''$ B.S.P.F., and the other end is screwed either into a $\frac{1}{2}''$ W. hexagonal adaptor $\frac{1}{2}''$ B.S.P.F. $\times$ $\frac{1}{2}''$ B.S.P.F. or direct into the body of a quick-turn "on and off" tap.

The ends of the lance and the recesses in the adaptors and tap are machined at right angles to the thread. After the screw thread and washer have been coated with a P.V.C. cement the lance tube is screwed up tight against a thin fibre washer; this procedure ensures pressure-tight and corrosion-resistant joints. Two rubber hand grips, each $6'' \times 1'' \times \frac{13}{16}''$ bore, are fitted over and cemented to the lance tube, one adjacent to the tap and the other 24″ from it.

The nozzle assembly, which screws on to the lance adaptor, comprises a brass nozzle adaptor (Fig. 6) into which a single nozzle is fitted at 45° to the length of the lance. The nozzle adaptor is bored and threaded $\frac{1}{2}''$ B.S.P.F. $\times$ $\frac{1}{4}''$ B.S.P.F. and is fitted with a tommy bar or lug bars so that it is easily removed by hand from the lance. The nozzle body (Fig. 4) is screwed into the $\frac{1}{4}''$ B.S.P.F. tapping, and soldered into position to prevent unscrewing. A long filter (Fig. 3) $6'' \times \frac{3}{8}''$ O.D. is inserted into the bore of the lance between the lance end adaptor and the nozzle adaptor. It consists of a $\frac{1}{4}''$ diameter tubular body with the wall of the tube slotted $5'' \times \frac{3}{3}\frac{}{2}''$ and covered with Monel metal cloth with 40 apertures of ·016″ square per linear inch. Three spacer bushes are fitted on the body to form a cavity beneath the gauze in order to obtain the maximum effective filtering area; the spray liquid passes through the gauze into the tubular body. A rubber washer $\frac{3}{4}'' \times \frac{3}{8}'' \times \frac{3}{1}\frac{}{6}''$ is fitted into the nozzle adaptor, making a leak-proof joint with the lance adaptor and filter top. The washer is a tight fit and therefore does not fall out when the nozzle adaptor is unscrewed.

The lance tap (Fig. 1) is of simple robust design and so arranged that the " on " and " off " positions are obtained by a half turn of a large wing-nut. The wing-nut operates a rod with a quick thread ; on the other end of the rod, inside the tap, is fitted a captive but floating phosphor bronze ball. When the ball is screwed on to the seat the flow of liquid is completely cut off from the lance : in the " on " position the ball is lifted well away from the seat to give a free flow of liquid. The entry way of the tap is either male-threaded or fitted with a male adaptor bush to suit the size and thread of hose-coupling nut, which may be $\frac{3}{4}$" B.S.P., 1" W., $\frac{3}{4}$" U.S.A., $11\frac{1}{2}$ t.p.i. hose-thread, or $\frac{1}{4}$" B.S.P., depending upon the purpose for which the lance is required and upon particular conditions in the country of use. The hose-coupling is a lug-nut for the $\frac{3}{4}$" and 1" sizes, with a tight fitting rubber washer which provides a leak-proof joint without the use of a spanner. The $\frac{1}{4}$" B.S.P. coupling is a lug-nut with a metal-to-metal 60° taper-fitting joint.

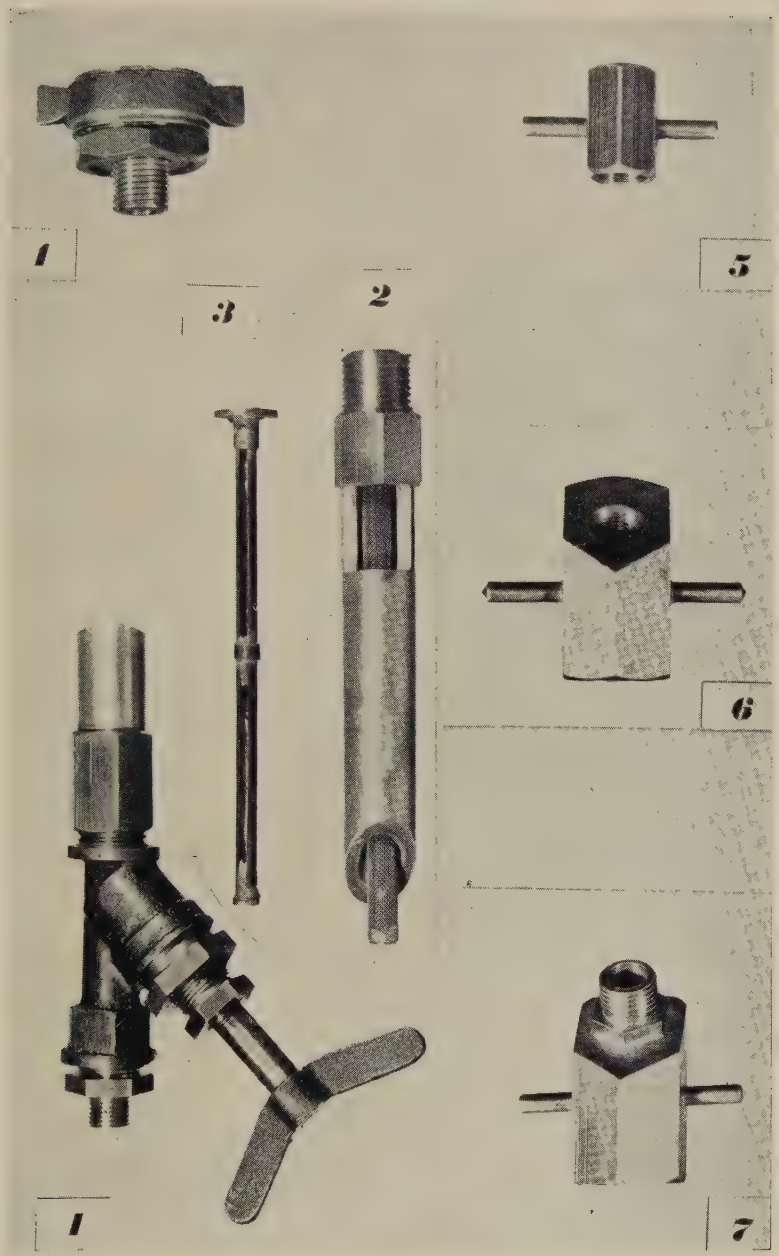
Either a $\frac{1}{4}$" B.S.P. (1) or $\frac{3}{4}$" B.S.P. type nozzle can be used as both have a $\frac{1}{4}$" B.S.P.M. thread for attachment. The larger size is more serviceable for rough use by unskilled native labour. The nozzle consists of a cap with lug-nut for easy removal, a stainless steel disc, a swirl chamber rubber gasket, and a swirl plate. A spray disc $\frac{15}{16}$" × $\frac{1}{32}$" with an aperture of $\frac{4}{64}$ or $\frac{5}{64}$" diam. covers most requirements, the larger size being used for low flow pressures. The rubber gasket is a tight fit in the nozzle cap to prevent the disc falling out during cleaning, and for the same reason the swirl plate is soldered into position. The choice of swirl plate depends on the flow pressure and the performance required. A plate of $\frac{3}{4}$" diameter × $\frac{1}{8}$", with 4 equidistant slots in the periphery cut $\frac{5}{32}$" deep × $\frac{3}{32}$" wide at an angle of 45°, is best for flow pressures up to 200 lb. p.s.i. A swirl plate with 6 equidistant slots in the periphery and a central hole of $\frac{7}{32}$" is suitable for flow pressures in excess of 200 lb. p.s.i.

Operation and Maintenance.

The lance can be used attached to various lengths of hose, which should be as light as possible and suitable for the particular throughput and flow pressure used. An unnecessarily large-bore hose is heavy and impedes the movements of the spraymen, thereby reducing the speed and quality of the spray application. In many instances a $\frac{1}{4}$" bore hose will be adequate for small throughputs with a pump pressure of 200 lb. p.s.i. or less. Throughput and flow pressure vary with the length of hose, and a length must be selected that provides effective nozzle performance. A high-pressure $\frac{3}{8}$" bore hose should be used for flow pressures greater than 200 lb. p.s.i., or on rough ground where a lot of pulling is needed. The lance requires very little maintenance. The long filter should be removed and cleaned regularly. After sulphur compounds have been used corrosion of the filter cloth will occur if it is allowed to remain long in the tube ; when the gauze cloth fails it should be replaced or a complete new filter fitted. A leak may develop in the gland of the tap control rod ; it may usually be stopped by screwing up the gland nut but, if it persists, the gland should be re-packed with graphited hemp. After long use the tap may fail to turn off the flow of spray completely, because of wear of the ball and seat ; the fault may be remedied by removing the gland assembly, refacing the seat with a special tool and fitting a new ball. The aperture of the spray disc gradually becomes enlarged and oval, especially if Bordeaux mixture is used, and the disc should be occasionally replaced.

PLATE XI

COMPONENTS OF THE SPRAY LANCE FOR TROPICAL CROPS.



(1) The quick acting " on and off " lance tap. (2) The top end of the lance sectioned to show the U.P.V.C. lining and long filter. (3) The filter body with gauze removed. (4) $\frac{3}{4}''$ B.S.P. nozzle with a lug-nut cap ; body threaded $\frac{1}{4}''$ B.S.P.M. for attachment to (6). (5) Holder for ceramic fan spray-nozzle. (6) Nozzle adaptor into which nozzle body is screwed ; the adaptor screws on to the lance. (7) Nozzle adaptor with $\frac{1}{4}''$ B.S.P. nozzle-body for attachment of (5).

Summary.

(1) A spray lance for use by unskilled labour on tropical crops is described.
(2) The nozzle assembly incorporates a large filter, the lance is lined with corrosion-resistant polyvinyl chloride and the tap is of simple robust design.
(3) All the components requiring cleaning can be removed by hand without the use of spanners.

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SPRAY APPLICATION PROBLEMS: XL. A LIGHTWEIGHT SPRAY LANCE.

By H. G. H. KEARNS and N. G. MORGAN.

Small spray lances are required for numerous duties, such as mosquito control and the spraying of tea, tobacco, market garden and greenhouse crops, strawberries, mushrooms etc. The application of small volumes of more concentrated spray liquids has given rise to the need for precision-made nozzles (1) of simple design and for special lances. A lightweight lance that can be comfortably held and manipulated in one hand is described; it is intended for use with knapsack and small power-sprayers (2).

Specification.

The lance comprises a lance tube to which are attached, by threaded brass adaptors, a trigger tap and filter at one end and a spray nozzle, set at an angle, at the other. The total length required may vary according to the particular circumstances; these can be met either by fitting the appropriate length of tube or by using an adjustable telescopic lance. For many purposes, however, a satisfactory compromise for utility and balance is a total length of 26–30″ and a weight of approximately 18 oz.

All screw threads are $\frac{1}{4}''$ B.S.P. except those of the brass tube, which are B.S. Brass thread (26 t.p.i.). All the $\frac{1}{4}''$ B.S.P. couplings are made leak-proof by fitting $\frac{7}{16} \times \frac{1}{4} \times \frac{1}{32}''$ fibre washers.

The lance tube.

The lance tube (Fig. 1 c) may be of $\frac{1}{4}''$, $\frac{5}{16}''$ or $\frac{3}{8}''$ O.D. × 18 G hard drawn brass, or of unplasticised P.V.C. tube $\frac{1}{2}''$ O.D. × $\frac{5}{16}''$ bore. The $\frac{3}{8}''$ brass tube withstands rough use but the $\frac{1}{4}''$ is much lighter, is more pleasant to handle and is excellent for spraying glasshouse crops and mushroom beds. The plastic tube is very light, flexible and readily bent to shape, but it is liable to fracture if the nozzle is screwed too tightly into the brass adaptor, and there is also a tendency for the adaptor to unscrew from the tube when the nozzle is undone. With reasonable care, however, the plastic tube gives entirely satisfactory service.

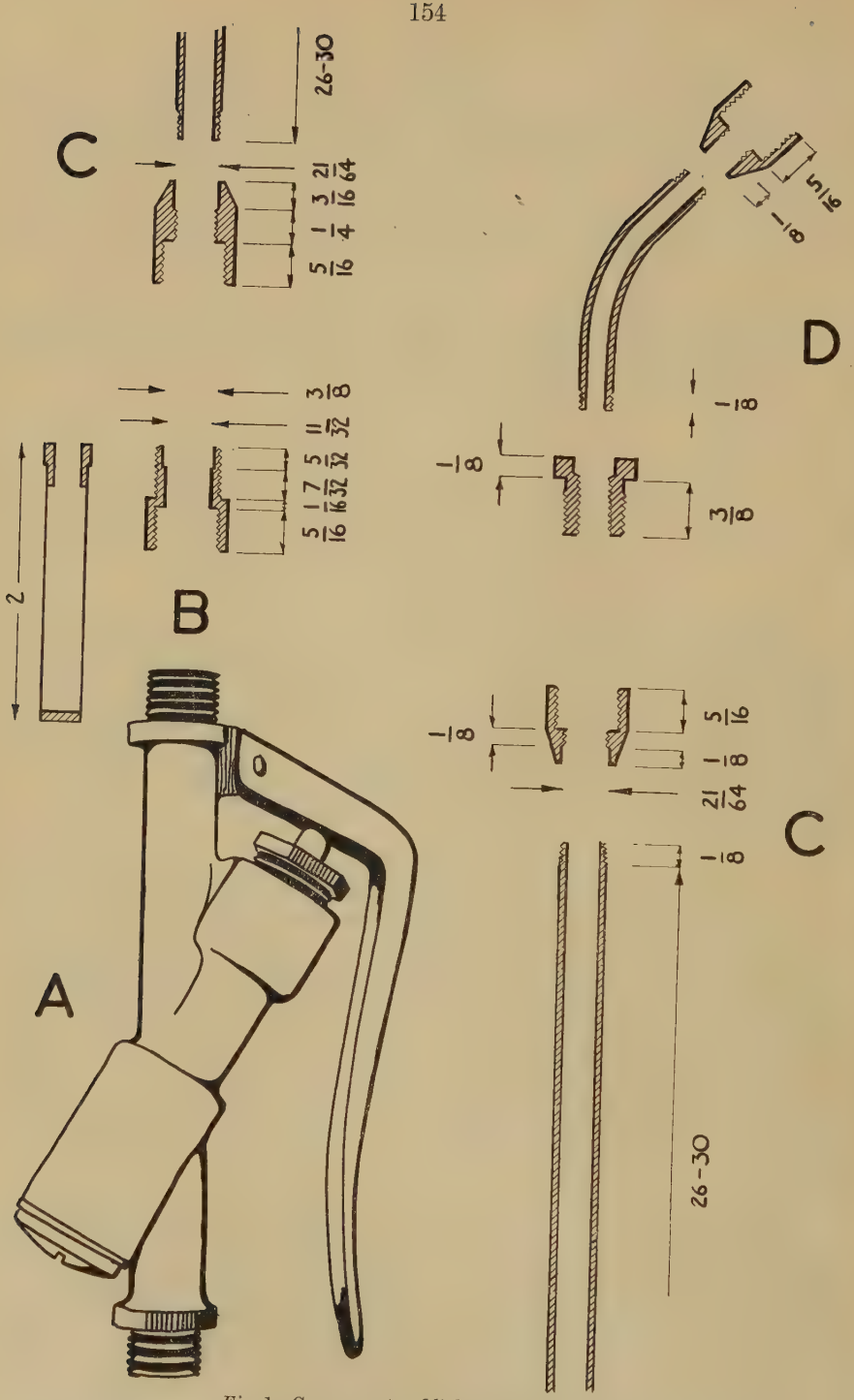

Fig. 1. Components of lightweight lance.
(A) Trigger tap ; (B) Filter unit comprising filter element and extractor body ; (C) Lance tube with adaptors ; (D) Nozzle bend with lance tube and nozzle adaptors.
All dimensions in inches.

The adaptors are made from $\frac{5}{16}$″ W. hexagonal brass bar, bored and threaded 26 t.p.i. at one end, to take the lance tube, and $\frac{1}{4}$″ B.S.P.F. at the other to take the nozzle or other component required. The adaptors are counterbored $\frac{1}{8}$″ deep so that a portion of unthreaded tube is within the adaptor when screwed home and soldered in position. This method of assembly ensures full support of the tube where it has been weakened by threading. The tube at the trigger tap end requires more support and here a longer adaptor is used. The counterbores for $\frac{1}{4}$″, $\frac{5}{16}$″ and $\frac{3}{8}$″ O.D. tubes are $\frac{1}{6}\frac{7}{4}$″, $\frac{2}{6}\frac{1}{4}$″ and $\frac{2}{6}\frac{5}{4}$″ respectively.

Nozzle bends.

The nozzle angle is obtained either by bending the tube at the nozzle end to $22\frac{1}{2}°$ or 45° from the straight or, when a choice of angles is desired, by using separate nozzle bends (Fig. 1 D) of $22\frac{1}{2}°$, 45°, and $67\frac{1}{2}°$, with adaptors to fit the nozzle and the lance tube. The size of tube used for the bends is the same as or smaller than that of the lance, and the adaptors are fitted in the same way.

Trigger tap.

The simple bronze trigger tap (shown in Fig 1 A) is 6″ long, weighs 13 oz., is comfortable to hold and requires little pressure to operate. The trigger lever actuates a rod which pushes a bronze ball off its seat, allowing the spray liquid to pass through. On release of the trigger lever the ball is returned to its seat by a coil spring, aided by the flow-pressure of the liquid, and makes a watertight seal. The push rod is fitted with a stuffing gland. The tap inlet is $\frac{1}{4}$″ B.S.P.M. counterbored 60° taper so that a metal-to-metal type of hose coupling can be used. The tap outlet is $\frac{1}{4}$″ B.S.P.M. and bored $\frac{1}{3}\frac{1}{2}$″ for the insertion of a filter element. The lance may be screwed direct on to the tap if a filter is considered unnecessary, for instance when swirl nozzles with disc apertures greater than $\frac{4}{6}\frac{}{4}$″ diameter are used.

Filter units.

The lance is held in one hand and it is important that the weight at the nozzle end be kept to a minimum. The most satisfactory position for the filter element is therefore within the body of the tap on the outlet side of the ball valve. A filter element 2″ × $\frac{5}{16}$″ O.D. made of Monel metal cloth with 40 apertures ·015″ square per linear inch is satisfactory. It is essential that the element can be easily extracted so that the gauze can be cleaned. This is arranged by fitting an adaptor (Fig. 1 B) between the lance and trigger tap to act as a holder and extractor.

If the design of the trigger tap is such that it will not hold the filter element it is necessary to provide an external filter body. This is of $\frac{5}{16}$″ W. hexagonal bar $1\frac{3}{4}$″ long, bored $\frac{1}{3}\frac{1}{2}$″ and each end tapped $\frac{1}{4}$″ B.S.P.F. for a depth of $\frac{5}{16}$″ with the bottom of the recess machined flat. One end is fitted with a standard nozzle body $\frac{1}{4}$″ B.S.P.M. × $\frac{1}{4}$″ B.S.P.M. through which a 2″ × $\frac{5}{16}$″ filter element is inserted and to which the lance is screwed. The other end of the filter body is screwed on to the trigger tap. The filter can be cleaned by first unscrewing the lance then extracting the element by unscrewing the standard nozzle body from the filter body.

The nozzle.

A $\frac{1}{4}$″ B.S.P. nozzle (2) of the swirl or fan spray type is fitted according to the particular duty.

Operation and Maintenance.

The spray lance is used in conjunction with $\frac{1}{4}''$ bore hose of the lightest type suitable for the working pressure. Braided hose is usually more pliable than wrapped hose. With insecticides in oils or solvents, hose of a suitable grade of synthetic rubber must be used. The hose is fitted with a $\frac{1}{4}''$ B.S.P. lug unit and a tail piece with a 60° male cone to form a metal-to-metal coupling with the trigger tap.

Filter gauzes must be regularly cleaned and, to prevent the corrosion that occurs in rest-periods, particularly after sulphur sprays have been used, they should be removed for storage.

Leaks of spray liquid through the trigger tap push-rod stuffing-gland are normally stopped by careful tightening of the gland nut. If they persist, the gland must be repacked with graphited hemp or asbestos and the gland nut adjusted to prevent leaks but still to allow the return of the push rod to the " off " position. If, after long use, the trigger tap fails to shut off the spray liquid, the ball seat must be refaced with a re-seating tool and a new ball fitted.

Summary.

(1) A specification is given for a light-weight spray lance suitable for one-hand operation with knapsack and small power sprayers.
(2) The lance comprises a brass or P.V.C. tube, a quick-acting trigger tap, a filter unit and a $\frac{1}{4}''$ B.S.P. swirl or fan spray nozzle set at an angle.
(3) All component parts are threaded $\frac{1}{4}''$ B.S.P.
(4) The lance has been designed for a wide range of light duties, including the spraying of market garden, flower and greenhouse crops, strawberries and mushrooms, etc., and for work overseas including mosquito control, and the spraying of tea and tobacco.

Acknowledgments.

Thanks are due to Mr. D. E. Aliband for the drawings.

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SPRAY APPLICATION PROBLEMS: XLI. MODIFICATIONS OF THE LONG ASHTON ¼″ B.S.P. SPRAY NOZZLE FOR SPECIAL REQUIREMENTS.

By H. G. H. KEARNS and N. G. MORGAN.

A lightweight spray nozzle described as ¼″ B.S.P. (1) has been made in considerable numbers. Since its introduction in 1949 experience at home and abroad has led to modifications and additions to satisfy special requirements. Care has been taken to avoid alterations that render the earlier design obsolete. The adoption of a male ¼″ B.S.P. parallel free-fit thread on the nozzle body, as a means of attachment to lances, booms, filter bodies etc., has proved, from practical experience, entirely satisfactory. Its size enables the nozzle body and other components to be manufactured, at reasonable cost, from 5/16″ W. (A.F.19/32″) hexagonal brass bar, a size that is adequate for field use. A female thread is essential in the adaptors on the components of spraying equipment most subject to hard field use, for example on the long booms used on ground crop sprayers, as it is protected against mechanical damage.

The modifications of the basic nozzle include an increase in the depth of the side slots of the large volume swirl plate and the addition of a long range tubular spray disc and a holder for ceramic nozzles and nozzle filter assemblies.

Modifications and Additions.

Swirl plate.

The depth of the two side-slots of the swirl plate used with disc apertures greater than 2/64″ has been increased from 3/32″ to 4/32″. This increases the throughput of disc apertures ranging from 3 to 8/64″, which were previously liable to starvation by the smaller slots.

Long range tubular spray disc.

The flat discs with apertures of 3 to 8/64″ diameter, normally fitted to the ¼″ B.S.P. nozzle, give a wide-angle hollow cone spray pattern. This pattern has a short range : for some purposes a longer range is desirable, for example, for the automatic spraying of pyramid apples and currants (2) under windy conditions ; the long-range disc is also useful for some targets when spraying with a lance. A common fault of swirl nozzles is that the droplets emerge in a hollow cone pattern and the target aimed at is unsatisfactorily sprayed. The long range disc produces larger droplets and a less hollow pattern.

A tubular disc (Fig. 1) with an aperture of 5 or 6 /64″ and a counter bore of 3/16″ deep × 5/32″ wide forms a satisfactory spray pattern at a flow pressure of 75 lb. p.s.i. A combination of nozzles with flat and tubular discs fitted alternately on a vertical " boom " or " mast " has proved most satisfactory for spraying small bush fruit as it ensures coverage of near and distant portions of the target. The tubular disc may be manufactured from turning-quality brass, Monel metal or stainless steel.

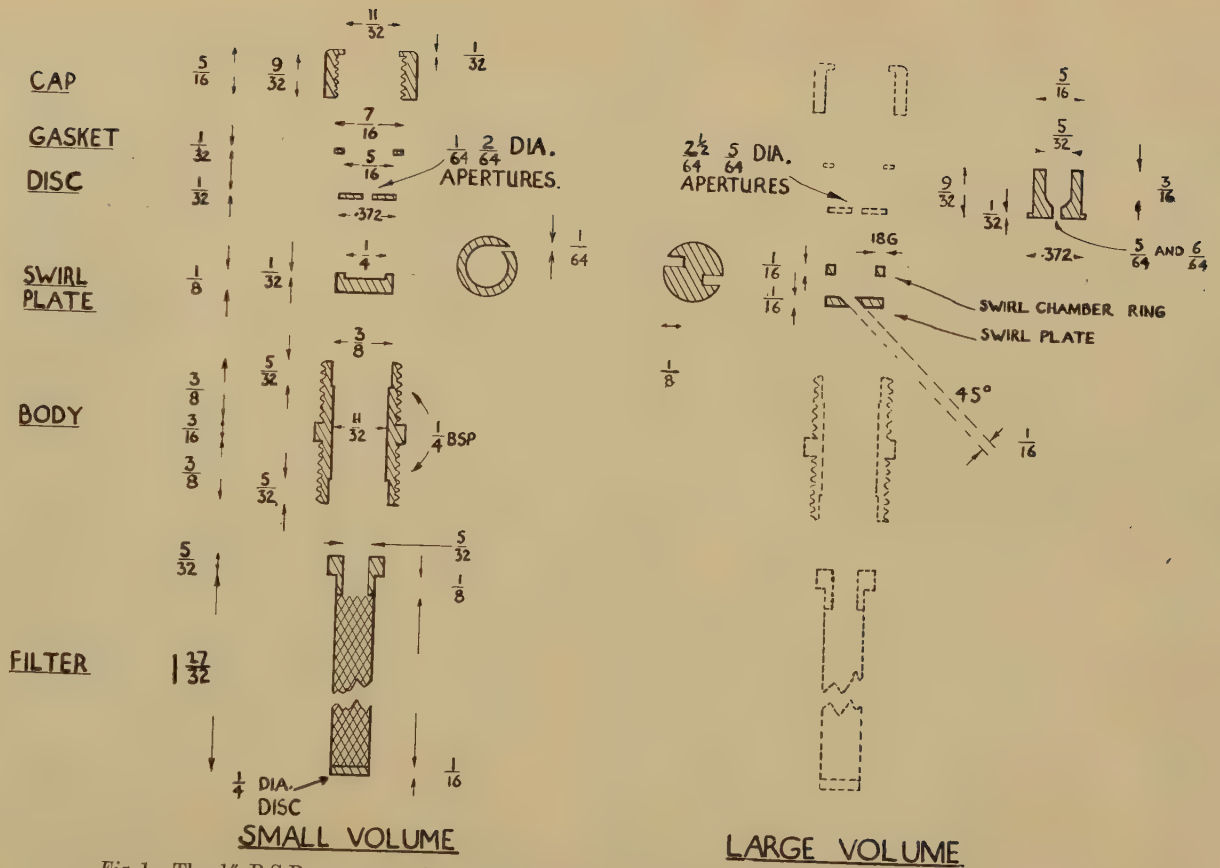

Fig 1. The ¼″ B.S.P. spray nozzle. Dimensions quoted in inches of the component parts of the swirl nozzle for small and large volume applications.

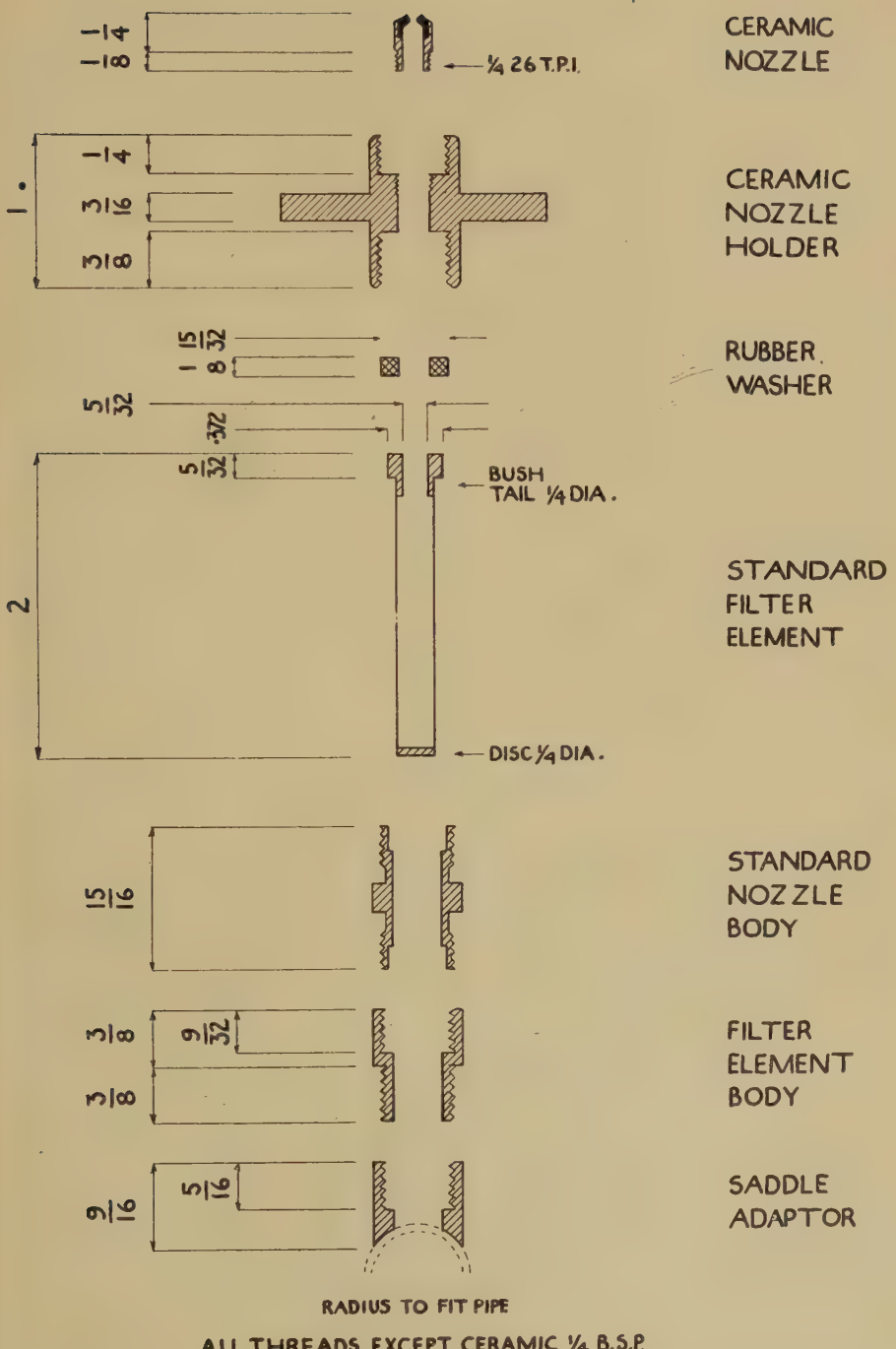

Fig. 2. The ¼″ B.S.P. spray nozzle. The dimensions quoted in inches of the components of the fan spray ceramic nozzle and of the filter assemblies.

A holder for ceramic nozzles.

Ceramic and metal flat-spray nozzles, producing a fan or batswing spray pattern, have gained favour for many purposes. The main reasons would appear to be their satisfactory performance at low pressures, the very low price of the ceramic type and, since the spray pattern is wider for a given throughput than that of a swirl-type nozzle, personal preference for such work as the application of DDT to walls for mosquito control. The throughput of liquid depends on the size of the aperture and on the flow pressure ; an increase in throughput due to increased pressure is not accompanied by much change in droplet spectrum.

The ceramic nozzle consists of a pallet of corrosion-and abrasion-resistant material mounted in a brass ferrule threaded at the base. The rectangular aperture in the ceramic is formed in a rectangular cavity whose depth, length and slope determine the fan spray pattern. These nozzles cost about twopence each and give a uniformity of performance satisfactory for all normal field spraying ; they are more abrasion-resistant than the metal types. The ceramic pallet mounted in a ferrule is available in 10 sizes of aperture, giving throughputs ranging from 3 fl. oz. to 3 pints per minute at 30 lb. p.s.i. The ferrule consists of a brass hexagonal ·248″ A.F. (4.B.A.) with a thread on the base of $\frac{1}{4}$″ × 26 t.p.i. (Fig. 2). The ceramic pallet protrudes from the brass ferrule and is readily fractured unless it is mounted in a suitable protective holder and, in common with all fan spray nozzles, it is readily blocked unless an efficient filter is fitted. It is a great convenience, particularly when the nozzles are fitted along a spray boom such as is used on field sprayers, if an easy method of aligning the fan pattern be provided.

A holder for the ceramic nozzle is shown in Fig. 2. It consists of a 1″ length of 5/16″ W. (A.F. 19/32″) brass hex. bar ; one end tapped $\frac{1}{4}$″ B.S.P. for $\frac{1}{4}$″ depth and counter-tapped in the centre $\frac{1}{4}$″ × 26 t.p.i. ; the other end tapped $\frac{1}{4}$″ B.S.P. for a depth of $\frac{3}{8}$″. The base of each recess of the $\frac{1}{4}$″ B.S.P. thread is end-milled 29/64″ to provide a flat surface. Either a 3/16″ diameter brass tommy bar or lugs are provided at the centre of the holder, or a slot 3/32″ wide × 3/32″ deep is milled across the centre of the holder at the end tapped for the ceramic ferrule. The ceramic nozzle is screwed into the holder and its position adjusted until the longer length of the rectangular aperture is at right angles to the line of the tommy bar or slots. The holder is then heated and a small amount of 22 wire-gauge flux-cored solder is melted on the bottom end of the ferrule. The solder forms a watertight seal and locates the ceramic ; the fan pattern then emerges in line with the tommy bar or slots.

The $\frac{3}{8}$″ end of the complete holder is fitted with a 29/64″ × 1/8″ × 3/16″ rubber washer which is a tight fit ; this forms a convenient means of making a leak-proof joint on the standard nozzle body and at the same time simplifies alignment of the flat spray. The end of the nozzle fitted with the ceramic is tapped $\frac{1}{4}$″ B.S.P. to provide a safe means of cleaning a blocked aperture. If a blockage occurs the holder is unscrewed, reversed and screwed to the nozzle body after removal of the filter element. The blockage is then readily cleared from the ceramic by blowing out with spray liquid at pressure.

Nozzle filter assemblies.

Blocked nozzles are a frequent source of delay in spraying operations, and the smaller the throughput of the nozzle, especially with field sprayers,

the greater the need for efficient filtering. Swirl nozzle disc apertures less than 4/64″ diameter, and all fan spray nozzles, are readily blocked by small particles. A spray machine should, in any event, be fitted with an efficient filter system with filters on the suction side of the pump, the entry to the spray tank and, in all automatic sprayers applying small volumes, on the entry to the "booms" or "mast". With small-aperture nozzles this system is insufficient in itself and each nozzle must have its own filter.

The provision of very fine mesh gauzes is a source of trouble with solid spray materials in suspension as, due to the low flow rate through the nozzle, the apertures become blocked by the aggregation of particles which, individually, are well able to pass through the apertures in the mesh; the apertures should therefore be only slightly smaller than the smaller dimension of the nozzle aperture. A filter element 2″ long × 5/16″ diameter has given satisfactory results and is of reasonable proportions for a $\frac{1}{4}$″ B.S.P. nozzle.

The design and dimensions of a filter element are shown in Fig. 2. It comprises a 2″ × $\frac{1}{4}$″ cylinder of gauze, one end of which is closed by a disc and the other soldered to a bush which fits into the recess of the $\frac{1}{4}$″ B.S.P. nozzle body. Monel metal woven cloths of two mesh sizes are used, one with forty ·0159″ square apertures per linear inch, which is adequate to protect nozzle disc apertures of 2/64″ and greater, and a second with a hundred ·005″ square apertures per inch, suitable for all smaller disc apertures. A common difficulty with tubular filter elements is their liability to become jammed in the nozzle body because of infrequent cleaning and subsequent corrosion. Therefore it is necessary to provide means of extracting the element. An assembly comprising a $\frac{1}{4}$″ B.S.P. nozzle body and three alternative lengths of filter body: 5/16″ W. hex × $\frac{3}{4}$″; $1\frac{5}{8}$″; or $1\frac{3}{4}$″ bored 11/32″; satisfy most requirements; the length is selected according to the nozzle assembly.

When a filter element is required for a ceramic nozzle on a spray boom, the filter is fitted into the top of a $\frac{1}{4}$″ B.S.P. nozzle body. This is screwed into a $\frac{3}{4}$″ long filter body and this in turn is fitted into a 9/16″ long boom saddle, also bored 11/32″; this assembly makes it possible to expose a considerable length of the gauze for cleaning. With a swirl nozzle, the filter element is fitted into the bottom of the nozzle body, which is screwed into a filter body of $1\frac{5}{8}$″ length. When used with either nozzle the filter element protrudes through the boom saddle into the bore of the boom itself.

When a filter is required on a lightweight lance, it is best fitted above or in a trigger tap; this arrangement avoids adding weight to the nozzle end of the lance and therefore aids manipulation. A filter body $1\frac{3}{4}$″ long $\frac{1}{4}$″ B.S.P.F. × $\frac{1}{4}$″ B.S.P.F. may be fitted above the trigger tap, while into the top of the filter body a standard $\frac{1}{4}$″ nozzle body is screwed; the filter element is inserted and the lance screwed to the nozzle body. The filter element is readily extracted by unscrewing the nozzle body from the filter body. Alternatively an adaptor (see Fig. 1B, p. 154) $\frac{3}{4}$″ long × $\frac{1}{4}$″ B.S.P.M. × $\frac{1}{4}$″ B.S.P.F. bored 11/32″ with the male end counter bored $\frac{3}{8}$″ × 5/32″, is screwed to the tap. A filter element is fitted into the adaptor and tap and finally the lance is screwed on to the adaptor. When the filter is fitted into the tap in this way, instead of immediately behind the ceramic nozzle holder, it is necessary to fit a brass bush 0·372″ wide by $\frac{5}{32}$″ deep and bored $\frac{3}{16}$″ into the top recess of the nozzle body. This forms a support for the rubber washer in the nozzle holder.

Materials.

The nozzle body, ceramic nozzle holder, filter body and nozzle cap should be made from 5/16″ W. (A.F.19/32″) hexagonal turning-quality brass. The Monel metal gauze filters will corrode, especially if used with sulphur-containing materials, and should be removed after use : they are readily cleaned in 10 per cent. hydrochloric acid, followed by dipping in 10 per cent. sodium carbonate solution.

Summary.

Modifications extend the uses of the Long Ashton $\frac{1}{4}$″ B.S.P. nozzle. They include a long-range disc, a protected and easily cleaned ceramic holder, and a filter.

Acknowledgments.

Thanks are due to Mr. D. E. Aliband for the drawings.

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THE AMINO-ACID CONTENT OF CIDER IN RELATION TO THE GROWTH OF LACTIC ACID BACTERIA.

By L. F. BURROUGHS and J. G. CARR.

In a previous article (1) it was shown that the growth of lactic acid bacteria in bottled ciders was directly related to the extent to which yeast autolysis had been allowed to occur during fermentation and storage of the cider in cask. Thus, a cider fermented to dryness and stored on its lees supported a large growth of bacteria after bottling, while a cider from which yeast had been removed by centrifuging during fermentation was resistant to bacterial growth. The amino-acid contents of these ciders were very different and probably had an important influence on their susceptibility to bacterial attack. In the present paper the relation between the amino-acid content of a cider and its ability to support bacterial growth is further studied using pure cultures of lactic acid bacteria.

Experimental.

1. *Preparation of juice and ciders.*

Eighteen gallons of Sweet Alford juice were depectinized by treating with 0·1% Pectozyme overnight. The clear juice was syphoned from the deposit, filtered through clarifying filter sheets (K5) and finally sterile-filtered (EK sheets) into four $2\frac{1}{4}$ gallon jars. These jars had previously been autoclaved at 15 lb. per sq. in. for 15 minutes. A reserve of sterile-filtered juice for later tests was stored in sterile jars at 0°C.

Each of the four $2\frac{1}{4}$ gallon jars was inoculated with a pure culture of a flocculating cider yeast, a sterile hydrometer was added and the jar was closed with a sterile rubber bung carrying a fermentation lock. When the cider in the first jar had fermented from S.G. 1,056 to 1,044, it was syphoned from its lees, clarified (K5 filter sheets), sterile-filtered and stored in sterile half-pint bottles at 0°C. The ciders in the second and third jars were treated similarly when they had fermented to S.G. 1,024 and 1,005 respectively. The cider in the fourth jar was allowed to stand on its lees for eight weeks after it had fermented to S.G. 1,005 before being filtered and bottled. Each of these four ciders and also the original sterile-filtered juice was examined chemically for its nitrogen and amino-acid content and was tested microbiologically for its ability to support the growth of lactic acid bacteria.

2. *Methods of chemical analysis.*

The methods used for determining the nitrogen and amino-acid contents of the juice and ciders have been described elsewhere (2). Soluble nitrogen was determined by micro-Kjeldahl digestion ; alcohol-soluble nitrogen was determined similarly after precipitating " protein " nitrogen by the addition of four volumes of alcohol. Amino-acids were isolated from the 80% alcoholic filtrate of the juice, or cider, by adsorption on Zeokarb 225 (H^+ form) and elution with ammonia. After concentrating the eluate, a suitable volume was applied to a chromatogram and run first in *n*-butanol-acetic acid and then in phenol-ammonia. The chromatogram was treated with ninhydrin and the relative amount of each individual amino-acid was assessed visually from the size and intensity of the spot.

3. *Growth tests with lactic acid bacteria.*

Duplicate 5 ml. samples of the sterile juice and of the four ciders were transferred aseptically to sterile test-tubes. Each sample was inoculated with a single loopful of a washed suspension of the following cider isolates, whose full characteristics are described elsewhere (3) : A. a non slime-forming strain of *Leuconostoc mesenteroides* ; B. a non slime-forming strain of *Lactobacillus pastorianus* var. *quinicus* ; C. a slime-forming strain of *L. pastorianus* var. *quinicus* ; D. an atypical strain of *Lactobacillus plantarum*. All tubes were incubated anaerobically at 25°C. for 7 days, after which the amount of growth was measured turbidimetrically with the aid of an Eel nephelometer. Uninoculated tubes of each sample were included in the tests, and the turbidity readings obtained from these blanks were subtracted from the readings obtained for the appropriate inoculated tubes. In order to standardize the results, the turbidity readings obtained for the growth of a given organism in the ciders were expressed as percentages of the turbidity produced by the same organism in the juice.

Results.

It will be seen from Table I that the soluble nitrogen content of the juice was very rapidly utilized for yeast growth during the first five days of fermentation. The juice contained relatively large amounts of amino-acids, especially aspartic acid, asparagine and glutamic acid, whereas the cider at S.G. 1,044 contained only small or trace amounts of most of the amino-acids present in the juice. In this connexion it should be noted that the cider chromatograms

represented 20 ml. of sample while the juice chromatogram represented only 5 ml. so that the amino-acid content of the ciders was magnified in relation to that of the juice.

Further fermentation, to S.G. 1,005, took place with little qualitative or quantitative change in the nitrogen content of the cider. The amounts of free amino-acids present in the ciders were extremely small and most of the soluble nitrogen content (approx. 2 mg.N/100 ml.) was due to substances other than amino-acids.

TABLE I.

CHANGES IN SOLUBLE NITROGEN CONTENT AND AMINO-ACIDS DURING FERMENTATION.

Days of fermentation	0	5	16	57	113
Specific gravity	1,056	1,044	1,024	1,005	1,001
Soluble N. (mg.N/100 ml.)	4.94	2.13	2.03	2.00	2.53
Alcohol-soluble N. (mg.N/100 ml.)	4.58	1.90	1.82	1.89	2.29
Vol. juice or cider equivalent to chromatogram	5 ml.	20 ml.	20 ml.	20 ml.	20 ml.
†*Amino acids*					
Aspartic acid	10	1	1	tr.	2
Asparagine	10	1	tr.	0	tr.
Glutamic acid	10	3	1	1	2
Serine	8	2	1	2	4
Glycine	0	tr.	tr.	1	1
Threonine	2	0	0	tr.	1
α-Alanine	4	tr.	tr.	2	6
β-Alanine	1	tr.	0	0	tr.
γ-Aminobutyric acid	3	tr.	0	tr.	2
Valine	2	0	0	tr.	2
*Leucine(s)	2	0	0	tr.	3
Proline	tr.	0	0	0	tr.
Methyl-hydroxyl-proline	small	med.	med.	med.	med.
Arginine	0	0	0	0	1
Lysine	0	tr.	tr.	tr.	3
Pipecolinic acid	tr.	2	1	1	1
Phenylalanine	0	0	0	0	1
Tyrosine	0	0	0	0	tr.
Unknown (near proline)	1	2	2	3	2
Peptide (near arginine)	1	1	1	tr.	1
Peptide (near glutamine)	0	3	2	1	2

†Visual assessments ; scale 0—10 ; tr.=trace.
*Leucine and *iso*-leucine are not separated by these solvents.

The autolysis of yeast, which occurred when the cider was stored on its lees for eight weeks, increased the soluble nitrogen of the cider from 2·0 to 2·5 mg.N/100 ml. The effect on the amino-acid content, however, was relatively much greater, and the range of amino-acids present resembled that in the fresh juice, although the nitrogen content of the juice was higher. Certain amino-acids present in the autolysed cider were not detected in the juice ; these were arginine, lysine, phenylalanine and tyrosine, which are characteristic of yeast autolysis.

Although the excretion of amino-acids was marked only after prolonged storage on the lees, there was a detectable increase in some amino-acids at an earlier stage. Thus, serine, α-alanine, γ-aminobutyric acid, valine and leucine(s) were more prominent in the cider at S.G. 1,005 than at S.G. 1,024.

The results of the tests of bacterial growth in the juice and the different ciders are recorded in Table II. Organisms A, B and C behaved similarly, showing maximum growth in the juice, minimum growth at S.G. 1,024, increased

growth at S.G. 1,005 and a further increase in the autolysed cider. For these three organisms the decrease in growth in the cider at S.G. 1,044 was very marked, and for A and B growth was in fact minimal. Organism D behaved differently and minimum growth was obtained in the autolysed cider.

The growth responses of organisms A, B and C in the different ciders were closely related to the presence of amino-acids, as shown in Table I. Thus, the greatly reduced growth in the ciders at S.G. 1,044 and 1,024 corresponded with extremely low contents of amino-acids, several of which were below the limits of detection. The absence of valine in these ciders may be of particular importance since this amino-acid is essential for the growth of all four organisms (3). The increase in growth of all organisms in the cider at S.G. 1,005 coincided with the reappearance of traces of serine, α-alanine, γ-aminobutyric acid, valine and leucine(s) due to the onset of yeast autolysis. The further increase in growth of organisms A, B and C in the autolysed cider (S.G. 1,001) corresponded with the richer and more varied supply of amino-acids previously noted.

TABLE II.

GROWTH OF LACTIC ACID BACTERIA IN STERILE-FILTERED JUICE AND CIDERS.

Days of fermentation	0	5	16	57	113
Specific gravity	1,056	1,044	1,024	1,005	1,001
Organism	Amount of growth				
A	100	33	33	67	100
B	100	36	36	43	50
C	100	27	18	42	68
D	100	67	42	50	33

The behaviour of organism D cannot be explained in terms of the supply of amino-acids since it showed minimum growth in the autolysed cider. Growth was determined here by some other limiting factor, which may have been the absence of fermentable sugars : glucose and fructose would have been completely removed by the prolonged action of yeast, and whereas organisms A, B and C can utilize the pentoses that are present in small amounts in dry ciders, D cannot. Other factors, such as B-vitamins, may also be concerned, and in some instances growth may be determined by the combined effect of more than one factor.

In consequence of the relation between the growth of these organisms and the amino-acid content of the medium, experiments were made to find which amino-acids were most readily utilized. Organisms C and D were grown in pure culture in 250 ml. portions of sterile-filtered juice. After 12 days incubation in deep culture at 30°C. each culture was centrifuged and the supernatant liquid examined for its nitrogen and amino-acid content.

The soluble nitrogen content of the juice was not greatly reduced by bacterial growth, the decreases (representing nitrogen removed as bacterial substance) being 0·39 and 0·47 mg.N/100 ml. for C and D respectively. The amino-acid content of the juice, however, was markedly affected, especially by organism C. Certain amino-acids were completely removed, others only partially or not at all, and some were excreted into the medium. The principal changes are summarized in Table III.

TABLE III.

CHANGES IN AMINO-ACIDS CAUSED BY THE GROWTH OF LACTIC ACID BACTERIA IN STERILE-FILTERED JUICE.

	Utilized	Excreted
Organism C	Aspartic acid Asparagine Glutamic acid Serine Valine *iso*-Leucine	α-Alanine Phenylalanine Unknown 1 Unknown 2 Unknown 3
Organism D	Asparagine Glutamic acid Serine Valine *iso*-Leucine	α-Alanine

It is noteworthy that the amino-acids removed from the juice by these organisms included serine, valine and *iso*-leucine (the latter two were completely utilized). These were virtually absent from the ciders at S.G. 1,044 and 1,024 in which bacterial growth was greatly reduced ; they were also among those amino-acids released by autolysis. These facts suggest that variations in the amounts of serine, valine and *iso*-leucine may have been responsible for the behaviour observed in the tests of bacterial growth.

The excretion of phenylalanine by organism C is of interest since it may be associated with the metabolism of quinic and shikimic acids which are known to be concerned in the biosynthesis of aromatic compounds by some bacteria (4). Organisms B and C have in fact been shown to metabolise quinic and shikimic acids, present in apple juice, although the significance of this in aromatic biosynthesis has not yet been established for these bacteria (5, 6, 7). In this connexion the nature of the unknown amino-acids requires further investigation, particularly that of Unknown 1. This substance was excreted in considerable amount and was second only to α-alanine in its intensity on the chromatogram.

The results of these experiments have confirmed previous observations (1) that the growth of lactic acid bacteria in cider is stimulated by the products of yeast autolysis. This is in accord with conclusions drawn by Kulka (8), who found that the addition of yeast autolysate to beers greatly accelerated the development of lactic acid bacteria.

In the present experiment the two stages at which bacterial growth was most active were in the fresh juice and in the autolysed cider. In practical cider-making, therefore, special precautions should be taken at these two stages in the fermentation of low-acid juices, where bacterial growth is likely to occur. Thus, all such juices should be sulphited before fermentation to inhibit lactic acid bacteria and prevent their competition with the yeasts. After fermentation, dry ciders of low acidity should not be left on their lees, since this encourages the development of bacteria and causes the acidity to be further reduced.

Summary.

(1) Changes in amino-acid content were investigated chromatographically during the fermentation of a low-acid apple juice.

(2) Growth of lactic acid bacteria in the juice and in the cider at four stages of the fermentation was related to the amino-acid content of the medium.
(3) During growth of a lactic acid bacterium in the juice certain amino-acids were preferentially utilized while others were excreted.
(4) The significance of these findings in practical cider-making is indicated.

Acknowledgments.

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A COMPARISON OF SOME VARIETIES OF VEGETABLES PRESERVED BY CANNING AND BY FREEZING: PROGRESS REPORT V.

By ALICE CRANG and MARGARET STURDY.

The quality assessment of some varieties of beans and spinach is reported. Average figures for colour, texture, flavour and percentage waste are given for different methods of preserving and for individual varieties that have been tested for 3 years.

Experimental.

Vegetables Used. All the vegetables were grown at Long Ashton, picked when at their prime and preserved without delay. Most varieties were picked on at least three days during the season.

Preservation and Judging Methods. The methods of canning, freezing and judging the preserved produce were the same as those used previously (1, 2).

Results.

Beans, Broad.

The 7 varieties of broad bean tested during the season all gave satisfactory products when frozen ; the average marks are given in Table I with comparative figures for 1955 and 1954. The beans were not canned, as previous results had shown that none of these varieties was suitable for canning (2). The wastage on podding averaged 62%, the range being from 53 to 70%.

Beans, French and Runner.

Fifteen varieties of French beans were preserved by canning and by freezing; three of these were "stringless" and required only the tips to be removed in preparation; five were prepared by removing the side strings as well as the tips; seven were prepared by both methods. The average waste in preparation when the strings were removed was 28% of the total weight picked, whereas when the tips only were removed the wastage was 8%. As there was very little difference between the quality scores for the two methods of preparation, the "stringless" scores have been used.

The average quality scores for French and runner beans are compared with those obtained in 1955 and 1954 in Table I; it will be seen that the frozen beans have again been preferred to the canned ones. The effect of different methods of slicing the larger beans has also been compared with last year's results: there was a preference in colour and texture for those thinly sliced, but no marked preference in flavour.

The varieties of beans that have been tested for three seasons and not previously reported are given in Table II. The three dwarf French beans were all stringless. Refugee, a small bean, was the best of the three for canning, but Bountiful and The Victory gave better coloured frozen products; the flavour of all three was fairly good after freezing.

The three runner beans, all of a climbing habit, needed to have the strings removed and to be sliced before being preserved. Scarlet Emperor, judged fairly good, was the best of the three when canned and White Monarch came next; Kelvedon Wonder was of only fair quality. All three froze well, Scarlet Emperor and Kelvedon Wonder giving unusually well-coloured products, though the flavour of the last was a little weaker than that of the other two.

TABLE I.

BEANS AND SPINACH: THE EFFECTS OF PROCESS METHODS ON QUALITY.

Vegetable	Year	No. of varieties	Colour		Texture		Flavour	
			Canned	Frozen	Canned	Frozen	Canned	Frozen
Beans, Broad Mature	1956	7	—	7.8	—	7.8	—	7.9
	1955	5	—	7.9	—	6.8	—	7.3
	1954	6	—	8.6	—	7.9	—	7.9
Beans, French Mature sliced	1956	15	6.7	7.7	7.5	8.0	6.7	7.6
	1955	10	7.0	7.4	7.7	7.7	6.8	7.1
	1954	4	5.9	7.5	7.3	7.5	6.7	7.5
Beans, Runner Mature sliced	1956	4	7.2	9.0	8.3	8.4	6.9	7.8
	1955	2	7.3	9.3	8.7	8.3	7.4	7.5
	1954	4	5.6	8.8	7.8	8.8	5.7	7.6
Beans, French & Runner Mature sliced thinly	1956	6	7.0	8.5	8.2	8.3	6.7	7.7
	1955	2	7.3	9.3	8.7	8.3	7.4	7.5
Mature 1″ slices	1956	6	6.4	7.5	7.7	8.0	6.4	7.9
	1955	2	7.0	8.7	8.8	8.4	7.5	7.7
Spinach	1956	5	5.8	8.5	7.8	8.2	6.7	7.9
	1955	3	5.0	8.5	7.9	7.5	6.7	7.0

Spinach.

The five varieties of spinach froze very satisfactorily, retaining an unusually good colour and good texture and flavour. In comparison, the canned spinach was very poor in appearance despite the addition of artificial colour, and the flavour was rated only fair. (See Table I).

The varieties Giant Savoy Leaf and Prickly New Giant have given similar results in the three years tested : both are very satisfactory for freezing Perpetual has been rated good, but a little lower in freezing quality than the other two ; it loses about three times as much as the others during preparation, but from the grower's point of view its long picking season makes it a very useful vegetable. The averages of three years' scores are given in Table II.

TABLE II.

MEAN MARKS FOR QUALITY OF VARIETIES TESTED FOR THREE SEASONS.

Variety	Colour		Texture		Flavour		Waste
	Canned	Frozen	Canned	Frozen	Canned	Frozen	% Total Weight
Dwarf French Beans							
Bountiful ..	6.4	7.7	7.6	8.0	6.9	7.4	10
Refugee	7.4	6.5	8.2	8.2	7.3	7.4	8
The Victory ..	6.9	7.7	7.8	8.0	6.7	7.4	8
Runner Beans							
Kelvedon Wonder	6.4	8.9	7.9	7.9	6.5	7.3	21
Scarlet Emperor	7.3	9.0	8.4	8.2	7.3	7.8	25
White Monarch ..	6.8	8.4	8.4	8.5	6.9	7.8	27
Spinach							
Giant Savoy Leaf	5.4	8.7	7.8	8.2	6.7	7.9	12
Perpetual ..	5.1	8.7	7.5	7.6	6.8	7.5	37
Prickly New Giant	5.5	9.0	7.4	8.1	7.1	7.7	11

Summary.

This report gives the quality assessment of 7 varieties of broad bean preserved by freezing, and of 15 varieties of French bean, 4 of Runner bean and 5 of spinach preserved by canning and by freezing. The wastage during preparation is noted. Comments are made on 9 individual varieties that have been tested for three seasons.

Acknowledgments.

We are indebted to members of staff for their regular participation in the quality tests.

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A COMPARISON OF SOME VARIETIES OF FRUIT PRESERVED BY BOTTLING AND BY FREEZING: PROGRESS REPORT VII.

By ALICE CRANG and MARGARET STURDY.

Trials of the preserving qualities of fruits made in 1956 have included 10 pear and 4 gage plum varieties preserved by bottling and by freezing, with and without the addition of ascorbic acid, and 4 raspberry and 15 strawberry varieties examined for their fresh fruit, bottling, freezing and jam-making qualities.

The pears, plums and Royal Sovereign strawberries were grown at Long Ashton, and the raspberries and other strawberries at the National Agricultural Advisory Service Sub-Centre, Starcross.

Preserving and Judging Methods.

Pears and plums, ripened at room temperature, were bottled in 30° Brix sugar syrup by the method used previously (1, 2). Pears to be frozen were peeled, halved, cored and packed directly into rigid plastic boxes containing syrup chilled to about 38°F., using 1 part fruit to 1.4 parts syrup; in half the containers ascorbic acid was added to the syrup at the rate of ½ gram per pint (approx. 480 p.p.m. of contents). To prevent the fruit from rising in the syrup a layer of crumpled cellulose tissue was placed in the box immediately prior to securing the lid with polythene tape and freezing. Whole plums were frozen with and without ascorbic acid in the same way. Pears and plums were subsequently thawed by standing the containers in warm water for about 2 hours; they were judged within ½ hour of thawing.

As in 1955, the raspberries and strawberries were transported in insulated boxes cooled with solid carbon dioxide; they arrived at Long Ashton in excellent condition. The quality of the fresh fruit was judged on the day of picking, but fruit for preserving was left in the boxes overnight. The average number of fruits per pound and the waste in the hulling of strawberries were noted. The bottling and freezing methods were the same as those used in 1955 (1), all the bottled fruit being stored at 38°F.

Jam was made from fruit frozen for 3–4 months then boiled with sugar in the following proportions:

Raspberry. 3 lb. of fruit brought to the boil, reduced to 2½ lb., 3 lb. of sugar added and the mixture boiled to 5 lb.

Strawberry. 3½ lb. of hulled fruit brought to the boil, 1½ lb. of sugar added, the mixture re-boiled and left overnight; next day a further 1½ lb. of sugar added, and the jam reduced to 5 lb.

The jams were stored in glass jars covered with parchment, one series of each variety being stored at room temperature and another at 38°F.

Pears, plums and jams were judged after 2 months and raspberries and strawberries after 3½ and 4½ months' storage respectively. The figures given in Tables I and II are the mean marks awarded by 12–14 members of a tasting panel using the method of marking described previously (3). 8.5 or more denotes outstanding quality; 8.4–7.5 good; 7.4–6.5 fairly good to fair; 6.5–5.0 poor; and below 5 unacceptable.

TABLE I.

PEARS AND GAGE PLUMS.

	Colour			Texture			Flavour		
	Bottled	Frozen	Frozen*	Bottled	Frozen	Frozen*	Bottled	Frozen	Frozen*
Pears									
Beurré Bedford	8.1	8.2	8.5	8.6	7.1	6.0	8.4	6.3	6.2
Beurré Hardy	8.3	6.8	7.2	8.4	7.1	6.2	7.4	6.8	7.0
Bristol Cross	8.1	7.5	7.8	8.2	6.4	6.4	8.0	6.8	6.2
Clapp's Favourite	8.6	7.6	6.8	6.6	6.6	6.6	6.9	6.1	6.4
Conference	7.4	6.5	8.0	7.8	6.2	6.3	7.6	6.5	5.9
Durondeau	7.6	7.5	9.1	6.9	6.5	7.1	7.0	6.4	6.3
Doyenné du Comice	8.6	5.8	8.3	8.1	6.2	6.0	7.9	7.3	7.2
Gorham	8.9	7.8	7.8	8.1	7.7	7.9	7.1	6.7	6.8
Louise Bonne	6.8	7.2	8.2	8.0	6.4	7.1	7.4	7.2	7.5
Williams' Bon Chrétien	8.7	6.5	7.8	7.9	6.8	7.3	8.1	6.8	6.8
Mean	8.1	7.1	8.0	7.9	6.7	6.7	7.6	6.7	6.6
Gage Plums									
Bryanston Gage	7.5	7.5	8.5	8.1	7.2	7.4	8.3	7.5	7.5
Cambridge Gage	6.9	7.1	6.9	7.2	7.4	7.4	8.3	8.3	7.8
Count Althann's Gage	8.7	9.1	8.9	7.7	7.3	7.4	7.9	7.6	7.6
Jefferson	8.4	7.5	8.5	7.2	7.1	7.1	8.0	7.9	7.8
Mean	7.9	7.8	8.2	7.6	7.3	7.3	8.1	7.8	7.7

* Ascorbic acid added to the syrup.

Pears.

The marks awarded to the bottled and frozen pears are given in Table I.

Preserving Methods.

By preventing the fruit from floating in the syrup whilst freezing, and by thawing it more rapidly, a better coloured frozen product was obtained than in previous trials (2). The addition of ascorbic acid to the syrup gave a further slight improvement in colour, but the texture of all the frozen pears was either too soft or too tough, and the flavour was weak. Individual comments on the freezing quality of varieties are not therefore given. Most of the varieties gave a very satisfactory product when bottled.

Varieties.

The following comments apply to varieties that have been bottled in three or more years.

Beurré Bedford. Good texture and flavour; rated highly for colour in two of the three years tested.

Beurré Hardy. Consistently good, but flavour not outstanding.

Bristol Cross. Good colour and texture; its aromatic flavour well retained in the bottled fruit.

Conference. Consistently of moderately good quality.

Durondeau. Similar to Conference.

Doyenné du Comice. Outstandingly good colour, but flavour sometimes disappointing.

Plums : Gage Varieties.

The quality assessment for the 4 varieties tested in 1956 is given in Table I.

Preserving Methods.

Bottled gages have again proved generally satisfactory, though the colour of one variety was only fair. Marks for texture were lost through toughness of the skins.

The method of freezing and thawing the gages used in these tests proved generally satisfactory without the addition of ascorbic acid, which tended to spoil the flavour. When the fruit was held for more than half an hour after thawing, oxidative changes caused discoloration and poor flavour ; these changes were retarded by ascorbic acid.

Varieties. The following assessment is based on 3–4 years' trial :

Cambridge Gage.	Variable in colour, but flavour good when bottled or frozen ; skins somewhat tough.
Count Althann's Gage.	Consistently bottled well ; frozen fruit good colour but flavour weaker than Cambridge Gage.
Jefferson.	Colour and flavour good in both methods of preserving ; skins rather tough.

Raspberries.

Raspberry trials previously reported (1, 2) included 8 varieties that had been under test for three years, and 6 for only two. Three of the latter were tested again in 1956 using Lloyd George as a control for the fourth consecutive year. The acidities (pH values) of the 4 varieties were found to be similar ; their sugar contents (soluble solids) varied with both variety and season (Table II).

Preserving Methods.

Bottled raspberries retained their colour well when stored in the cold and were generally rated higher for flavour than the corresponding fresh or frozen fruit. Freezing seemed to enhance fruit colour.

Varieties.

Lloyd George.	The dark colour of this fruit is an advantage when preserved; it has been judged one of the best flavoured raspberries throughout. Its small size compared with most newer varieties should be noted.
Malling Y.	Fairly good appearance but flavour again proved weak.
Malling Z.	The fruit was too pale and fresh fruit flavour not generally liked.
Milton.	Disappointing as fresh or preserved fruit.

Strawberries.

The assessment of the 15 strawberry varieties as fresh, bottled and frozen fruit, and as jam (12 varieties only) is given in Table II. Most of the named varieties had been included in these trials before, but several Cambridge Seedling varieties were included for the first time. Royal Sovereign strawberries from Long Ashton were included for comparison.

TABLE II.

RASPBERRIES AND STRAWBERRIES.

Variety	Colour				Texture			Flavour				Fresh Fruit		
	Fresh	Frozen	Bottled	Jam	Fresh	Frozen	Bottled	Fresh	Frozen	Bottled	Jam	Average no. per lb.	Soluble solids %	pH value
Raspberries														
Lloyd George	7·9	8·4	8·2	—	8·1	8·1	8·4	7·3	8·3	8·5	—	206	8.5	3·1
Malling Y	7·0	8·0	6·6	—	7·7	8·0	7·4	6·8	6·6	6·7	—	136	9·5	3·1
Malling Z	6·2	7·2	6·3	—	6·8	7·3	7·5	4·8	6·8	7·2	—	160	9·5	3·1
Milton	6·7	7·3	6·9	—	7·9	7·8	7·2	6·3	6·3	7·6	—	144	10·0	3·1
Mean 1956 (4 varieties)	7·0	7·7	7·0	—	7·6	7·8	7·6	6·3	7·0	7·5	—	162	9·4	3·1
Mean 1955 (14 varieties)	7·6	7·6	7·6	—	7·9	7·1	7·5	7·2	7·0	7·6	—	—	8·5	3·1–3·5
Mean 1954 (15 varieties)	7·5	7·3	6·1*	—	7·6	7·2	6·8*	6·0	6·9	6·9*	—	—	8·1	3·0–3·4
Strawberries														
Cambridge Early	8·1	6·5	7·3	—	7·7	7·2	7·3	6·3	7·2	7·0	—	37	—	—
Cambridge Favourite (422)	7·5	7·2	6·7	5·5	8·3	7·8	8·0	7·1	7·5	7·2	6·9	29	—	3·5
Cambridge Premier	7·6	6·8	6·1	6·1	8·0	7·8	7·2	7·8	7·5	6·8	7·3	30	9·0	3·4
Cambridge Prizewinner (134)	7·8	8·6	7·0	6·9	7·6	7·7	7·4	6·4	7·4	6·6	6·6	41	9·5	3·5
Cambridge Rearguard	9·0	7·5	6·8	8·1	7·6	7·6	7·5	6·8	7·0	7·3	7·1	22	8·5	3·3
Cambridge Rival (632)	6·7	6·6	7·3	7·9	8·4	8·2	7·8	7·3	6·5	7·0	7·2	30	9·0	3·6
Cambridge Sentry	9·3	8·3	7·2	8·0	8·1	7·9	8·0	7·4	7·3	7·8	7·1	33	8·5	3·6
Cambridge Vigour (C.1.)	9·4	8·0	8·2	8·1	8·9	8·3	7·9	8·2	7·4	7·7	7·4	33	8·0	3·4
Cambridge A 141	7·7	6·5	7·2	—	7·9	7·5	8·1	6·8	6·5	6·8	—	39	9·0	3·5
Cambridge A 315	7·3	7·2	6·2	8·1	8·3	7·6	7·9	7·7	7·3	7·2	7·2	31	8·8	3·4
Cambridge A 318	8·4	7·9	6·6	—	8·2	7·6	8·0	7·8	7·6	7·8	—	42	11·0	3·4
Cambridge A 519	8·1	7·2	8·0	8·4	8·8	7·8	7·7	7·9	6·8	6·6	7·5	49	9·8	3·5
Cambridge A 650	7·2	7·8	7·0	7·5	8·5	8·3	7·7	7·6	7·7	7·3	6·6	39	9·0	3·5
Cambridge A 712	7·3	7·7	8·0	7·3	7·7	7·7	7·8	7·4	7·5	7·0	7·5	37	9·0	3·3
Royal Sovereign	—	7·3	6·2	—	—	7·8	7·6	—	7·5	7·5	—	35	9·5	3·4
Mean 1956 (15 varieties)	8·0	7·4	7·1	7·4	8·2	7·8	7·7	7·3	7·2	7·2	7·1	35	9·1	3·3–3·6
Mean 1955 (9 varieties)	8·0	7·0	7·8	—	8·1	7·2	7·8	7·8	6·4	7·4	—	—	8·3	3·3–3·5
Mean 1954 (9 varieties)	7·6	7·1	—	—	7·9	6·9	6·5*	6·9	6·1	6·0*	—	—	7·7	3·4–3·7

* Stored at room temperature.

The average weight of fruits from the different varieties varied from 22 (Rearguard) to 49 per lb. (Cambridge A 519).

The percentage of waste in hulling the fruit was greatest in the varieties Cambridge Favourite and A 650 (3%) and least in Cambridge Rival (1.5%). The range of acidities was similar to that in the two previous years but the sugar content was higher reflecting the good growing conditions at Starcross in 1956.

Processing Methods.

The figures show a slight preference in colour for frozen fruit over bottled fruit stored in the cold, a reversal of the order given last year ; both are much better than the figures (mean score=6·7) for bottled strawberries stored at room temperature in 1955. There is little difference in average marks for texture and flavour, both being lower than those for fresh fruit.

Marks awarded for jam colour and flavour are reported for the first time.

Varieties. Five of these varieties, included in these trials for 3 or more years, have been judged as follows :

Cambridge Favourite (422).	The appearance of the fresh, frozen and bottled fruit has generally been satisfactory, but the jam colour poor. The flavour has varied between good and weak.
Cambridge Prizewinner (134).	The colour of the fresh and frozen fruit has been good or very good, and fairly good in the bottled fruit and jam, but the flavour has been weak throughout.
Cambridge Rival (632).	The dark colour of this variety has been considered unattractive as fresh or frozen fruit, but better when bottled and made into jam. Flavour fairly good except in the frozen fruit, in which it was poor.
Cambridge Vigour (C.1.).	One of the best varieties for appearance as fresh or preserved fruit, the frozen fruit retaining its shape well after thawing. Flavour good in fresh and bottled, fairly good in frozen fruit and jam.
Royal Sovereign.	One of the best flavoured varieties when fresh or preserved, but the fruit breaks down on thawing and lacks colour as jam.

Summary.

The quality assessments of some varieties of pear, gage plum, raspberry and strawberry are discussed and compared with results previously obtained.

Most of the pears and gages had previously bottled satisfactorily, but had proved unsuitable for freezing because of the rapidity with which they oxidise. The addition of ascorbic acid to the cooled syrup helped to preserve colour, but it adversely affected flavour. By rapid freezing and thawing, and by ensuring that the fruit remained immersed in the syrup, satisfactory results were obtained with these fruits.

The qualities of raspberries and strawberries have been assessed as fresh fruit, frozen, bottled and as jam, and figures are given for the average number of fruits per pound, pH values and "soluble solids" content. A brief description is given of those varieties that have been tested for 3 or more years since 1950.

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METEOROLOGICAL RECORDS, 1956.

Month	Air Temperature (F°.)							Rainfall (″)			Sunshine (hours)		Soil Temperature at 09.00 G.M.T.		
	Means		Means of A&B	Diff. from normal	Max.	Min.	No. of ground frosts	Total	Per cent. of average	Most in a day	Daily mean	Per cent. of average	4″	8″	24″
	A Max.	B Min.													
January	46.1	34.6	40.3	—0.1	55	33	20	4.01	119	0.72	1.47	95	39.5	39.7	43.6
February	37.7	26.2	31.9	—8.8	50	11	24	0.20	7	0.10	2.37	100	33.7	34.9	40.0
March	51.8	35.3	43.6	—0.3	60	23	24	0.99	43	0.23	4.45	114	42.8	43.3	42.1
April	54.9	36.7	45.8	—1.8	65	30	20	1.92	95	0.38	5.62	103	45.5	45.1	46.7
May	63.1	44.3	53.7	+0.6	72	32	10	0.50	19	0.26	7.65	122	54.9	53.5	53.1
June	64.7	49.2	56.8	—1.7	74	36	2	2.78	132	0.52	5.09	73	57.5	57.3	57.7
July..	68.6	53.9	61.3	—0.2	81	43	0	4.26	135	2.32	5.35	84	61.1	60.7	61.6
August	64.6	50.5	57.6	—3.4	70	43	0	7.99	219	3.24	5.66	95	57.5	57.4	61.3
September ..	64.6	51.8	58.2	+1.1	75	43	1	3.55	112	0.64	2.53	54	56.9	57.0	59.5
October	57.7	42.9	50.2	—0.9	66	30	12	1.40	36	0.61	3.22	98	49.5	50.6	57.5
November	49.7	38.2	43.9	—1.7	59	26	11	1.07	29	0.29	1.51	80	43.2	44.3	49.7
December	48.1	38.5	43.4	+1.9	56	23	7	4.12	115	0.76	0.56	38	42.5	43.1	46.4
Totals or Means ..	56.0	41.8	48.9	—1.2				32.79	88		3.79	90	48.7	48.9	51.6

G. E. Clothier.

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The current Volume XXXII (1957) contains papers from both the sponsor Research Stations, from the John Innes Horticultural Institution, Scottish Horticultural Research Institute, National Vegetable Research Station, Reading and Nottingham Universities, Wye College, Ditton Laboratory, the N.A.A.S., and from the Transvaal and the West African Cocoa Research Institute. The list of subjects is a wide one; there are papers on rootstock/scion relations; pruning; propagation of apple rootstocks and gooseberries from cuttings; nutrition of fruits and vegetables; citrus rootstocks; pear viruses; apple sawfly and winter moth; the nature of resistance of cider apple varieties to Brown Rot; fruit development in relation to plant hormones; weedkillers; the effects of water regimes on tomatoes and lettuces; blindness in cauliflower; factors affecting the flowering of raspberries and chrysanthemums; induced polyploidy in *Theobroma cacao*.

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